Saskatchewan
Agriculture, Food
and Rural
Revitalization

ADF

AGRICULTURE DEVELOPMENT FUND

FINAL REPORT

19980082

DOMESTIC FRUIT DEVELOPMENT PROGRAM

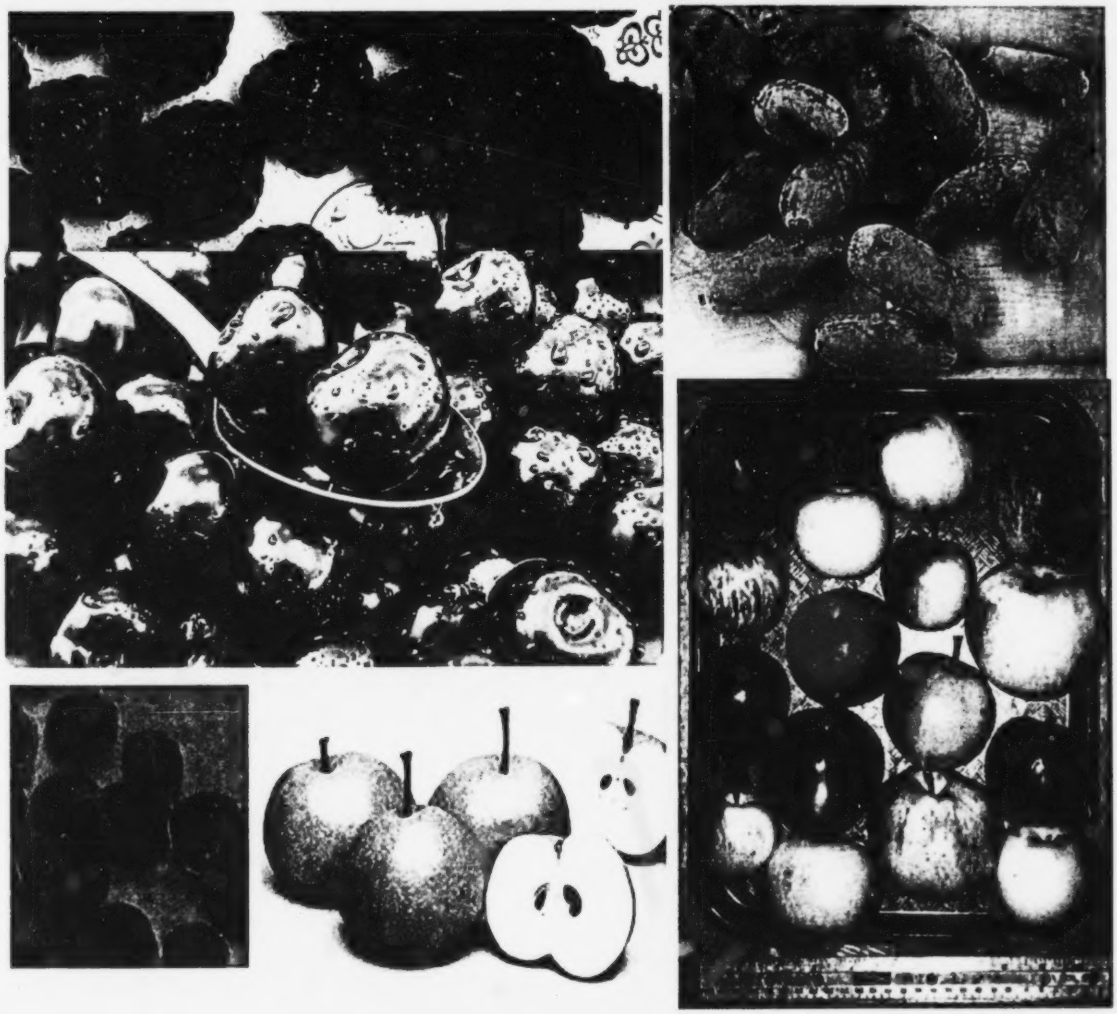
Funded by:
The Agriculture Development Fund

May 2003
Prepared by: University of Saskatchewan

103-06632/

Domestic Fruit Development Program

ADF # 98000082 Final Report, 2003



Funded by:
Agriculture Development Fund (ADF)

Report Prepared by:
Bob Bors, Rick Sawatzky, Forrest Scharf,
Heather Hack, Heather Drysdale, and Megan Payne

REGINA, SASK.
S4S 0B1

Domestic Fruit Development Program
(ADF Project # 19980082)
Executive Summary

Development of Fruit Cultivars

The following section summarizes the various crops which received attention in this project.

Dwarf Sour Cherries: These cherries were found to have higher sugar content, better colour, better flavours and in some cases larger fruit size than Montmorency (#1 cultivar in North America). It was discovered that our cherries have great potential for over-the-row harvesting whereas traditional Montmorency needs specialized equipment. Publications by others show Montmorency has a sugar content of around 11 to 14 brixs while most of our selections were 17 to 22 brixs. Our selections do not fall off easily after attaining peak colour. Rather they increase gradually in sugar content and do not show signs of desiccation until 3 weeks later. Fruit retention force remains similar during that 3 week period, and easily within the levels required for using an over-the–row harvester. Harvesting can be done once over as this crop is relatively uniform in ripening (unlike saskatoons which require multiple harvests). Change of acidity varies with some selection increasing and others decreasing after attaining colour. The dwarf stature of our cherries is unique, and highly desirable. Only one other breeding program (Sweden) has incorporated dwarf size into their sour cherries.

Apples: Studies revealed that advanced selections from the breeding program were superior to named prairie cultivars in flavour, crispness, and storage life. So many superior selections were found that repeated testing was done to narrow the list from 60 promising varieties to 'most promising' list of 10. Fresh taste equaled or surpassed common store varieties with the better selections. Apples have few pest and have potential for organic production. Early stages of the project relied on the breeders evaluating fruit quality. The last two years evaluations were also done by growers and various volunteers in the Plant Science Department. Overall, our tasters were quite impressed with the quality of our apples, indicating that the fruit quality would be acceptable in the marketplace. Storage experiments revealed that some selections could be stored until January in a cooler and could probably be held longer if we had Controlled Atmosphere Storage. It is likely that our apples will not store as long as other cultivars grown elsewhere in Canada, but recent selections probably have 2 months longer storage life than older selections.

Raspberries: Three raspberry varieties were released to 2 propagators. Initial observations by growers trying our varieties indicated that SK Red Mammoth was preferred over SK Red Bounty. However, an infestation of crown gall required clean-up via tissue culture and further propagation in culture. This activity is still in progress. Fields of our seedlings being grown by co-operators were evaluated and a few selections were obtained.

Plums: Observation of Plum material at the U of S indicated that most selections were of poor quality and that none of the material would be competitive in the marketplace. Some selections of high quality lacked proper size or had very tough skin. It was decided that crops required a new germplasm to introgress higher fruit quality and would likely need a few generations of improvement.

Cherry Plums: This crop is a type of dwarf plum which results from crossing Sand Cherries (a very dwarf plum) with Plums. Similar to plums mentioned above, these varieties were found to be lacking in quality. All varieties in our collection have similar black skin and most are bitter unless processed. A new sandcherry collection was gathered from many sources for use in breeding. Of special significance are yellow and red fruited sandcherries discovered by Dwayne Barber that will allow for breeding of light coloured cherry plums in the future.

Black Currents: Breeding work is not needed in this area as most black current varieties are very hardy, and new accessions recently introduced from Scotland ('Ben' series) are both flavourful and disease resistant.

Honeysuckles were found to be quite interesting as they are the first fruit to ripen and may be mechanically harvested. We were impressed with the 'Blue Belle' and 'Berry Blue' varieties, but found 'Blue Velvet' and 'Blue Bird' to be lacking.
More varieties need to be tested from Russia, and production guidelines developed. Breeding work is indicated to develope late fruiting varieties to extend the season. 15 new varieties from Russia and 20 seedling lines from USDA were obtained during the last months of this program.

Hazelnuts and pear selections were found that had excellent quality but lacked cold hardiness. Crosses were made in these populations which could result in selections in the next generation.

Strawberries were not considered in this project since 3 other grants were investigating strawberries.

Project Focus

As studies evolved over the project duration, it became clear that the crops with the biggest potential would be those that could be mechanically harvested or those that could be grown organically. The Dwarf Sour Cherries fit both categories and probably have the greatest potential of all fruit in this program. Apples, if grown organically may have the next greatest potential for commercialization. Thus cherries and apples were emphasized in much of the research for this project. Of secondary importance are blue honeysuckles and hazelnuts, which may be next in line for testing on a commercial level. The strategy adopted by the program was to emphasize those crops closest to commercialization which breeding other crops on a rotating basis.

Seedlings planted

Over 54,800 seedlings were planted for the fruit breeding program during this project. One third of these were planted at the University while $2/3^{rds}$ were distributed to co-operating growers. In most years controlled crosses of Dwarf Sour Cherries and Apples were done. Pears, plums and blue honeysuckles were also hybridized and planted.

New varieties

Five new fruit varieties were released in 1999: Sk Carmine Jewel (dwarf sour cherry), Sk Prairie Sun (Apple), SK Red Mammoth (Rasp.), SK Red Bounty (Rasp), and SK Steadfast (Rasp). These new varieties were propagated, descriptions published and promoted to the fruit industry. Royalties from these varieties have helped pat for virus-free certification and applications for plant breeder's rights.

In 2002, five sour cherry selections were released to propagators as part of a co-operative breeding project. Preliminary applications for plant breeder's rights for these were submitted. Eight nurseries have signed contracts with the university to propagate these selections. Other contracts are pending.

Propagation

Tissue culture and cutting propagation protocols were developed for the cherries. This information was distributed to companies with contracts for propagation rights.

Workshops to teach budding techniques were given in 2001 and 2001 to interested growers with attendance around 100 each year. A new technique involving parafilm (instead of the more awkward rubber bands and grafting wax) were demonstrated and taught to growers testing our selections.

Experiments of 5 fruit species showed that 'difficult varieties' such as Ottawa 3 apple rootstock could be rooted if juvenile shoots were used.

Fruit Quality & Processing

In addition to fresh quality listed above, cherries were evaluated for water retention after freezing. It was found that our cherries retained 60% of their weight while Evans (a likely offspring of Montmorency) retained only 40%. This test could indicate our cherries will hold up better under processing.

A student thesis was done on feasibility of using our cherries for beverages. Cherry juice of various sections was compared to various store bought products.

The study indicated that our cherries' juice was superior and highly concentrated compared to fruit juices found in stores. On average, sugar levels were 40% higher, acidity 300% higher and colour much more intense. It is likely that the cherry juice could be diluted in half with water and still be an acceptable product, but further research is needed. All commercial 'cherry drinks' had dyes added to make them red; this would not be needed with our cherries.

A study showed that delaying processing of picked cherries by as much as 5 days showed no significant decreases in quality.

Previous studies of apple processing were made available to growers but were not repeated in this project. It was noted that the new apple variety SK Prairie Sun may be uniquely adapted for drying since it does not readily discolor when cut open.

Test Marketing

Investigation of Saskatoon grocery stores showed few sour cherries were available. No store had frozen cherries. Whole, canned sour cherries were imported from Poland and Hungary but none were available from Canada or the US. Canadian and US sour cherries were mainly sold as pie filling or jam. In most cases 'cherry drinks' were artificially flavored. Only one cherry pie brand was available. This preliminary investigation seems to indicate that there is a lack of sour cherries available in the marketplace and/or that sour cherry producers in North America have not marketed their cherries very well. A report of this information was given at 3 grower's meetings.

Sour cherries (fresh, frozen, jam and juice) were given as samples at perhaps 20 events over the last 4 years including the annual Saskatchewan Horticulture Fair in Saskatoon, meetings of the Saskatchewan Fruit Growers Association, departmental events, workshops and field days. In all events the cherries were enthusiastically received by most people. I would estimate that 75% of people find them acceptable for fresh eating and that 25% find them too sour.

Cherry samples were taken to Homestyle Beverages which processed a sample batch which they found to be of excellent quality. Frozen cherries were made available to some of our propagators to assist in the promotion of their plant sales.

Dawn foods found our cherries to be too dark for their product and suggested that we investigate our lighter cherries to fit their needs. They required 2000 lbs of fruit for a test run, which we did not have. They suggested that our cherries would be a completely new line requiring additional marketing. They were enthusiastic about cherries in general stating that "there are only 3 flavours that the market is mostly interested in: Cherry, apple and blueberry; everything else is of minor importance". They also suggested we investigate the firmness of our apples and cherries after cooking. They mentioned they could use a good quality apple, locally produced, for processing.

In a similar, but smaller scale, apples were available at perhaps 10 events including the Crop Production Show, Seager Wheeler Farm, and fruit grower events.

Extension

The program was involved in over 46 grower-related events, with over ½ of these giving talks or demonstrations. Displays were frequently set up. The head of the program, Dr. Bob Bors is on the board of directors of the Saskatchewan Fruit Growers Association. Bob and Rick Sawatzky are members of the orchard committee of the Seager Wheeler Farm.

Currently over 140 growers are on our co-operator list with most of these growing seedlings or testing our advanced selections. Handouts, phone calls, and occasionally visits are done with our co-operators to address their needs. 12 of these co-operators are nurseries. Our strong grower base and contributions of their volunteer time have enabled our breeding program to operate at much lower costs than most breeding programs while allowing a far greater number of seedlings to be grown.

Nine articles were written during this grant. Perhaps 12 interviews with the press resulted stories published in the Western Producer, Star Phoenix, local papers, CBC radio and CBC TV.

TABLE OF CONTENTS

INTRODUCTION 4

PROJECT SUMMARY 7

PROJECT PERSONNEL 9

PROJECT GOALS 9

RESEARCH SECTION 9

Chapter 1. PROPAGATION 10
- Seedlings germinated for Fruit Breeding 10
- Testing of three hormone preparations on juvenile cuttings of Ottawa-3 apples, Dwarf Sour cherries, Hazelnuts, double-flowered plums, and saskatoons. 10
- Hardwood Cuttings of Ottawa 3 19
- Parafilm wrap for grafting 19
- Apple Cultivar Conversion Experiment 19
- Propagation of Dwarf Sour Cherries 20
- Seed germination 20
- Tissue Culture 21

Chapter 2. DWARF SOUR CHERRIES 26
- Germplasm Development and Breeding 26
- Cherry germplasm 32
- Mechanical harvesting studies on dwarf sour cherries 33
- International Cherry Symposium, October 2001 35
- Dwarf Sour Cherry breeding at the University of Saskatchewan (paper) 37
- Cherry processing 44
- Affect of delay in processing, April 2002 47
- Co-operative fruit breeding project, 2002 47
- Cherry Propagators, 2002 49
- Dwarf Sour Cherry Breeding, 2002 50
- New Seedling Orchard Established 51
- Five new sour cherry varieties 51

Chapter 3. BLUE HONEYSUCKLE *Lonicera cerulia* 53

Chapter 4. HAZELNUTS *Corylus hybrids* 58

Chapter 5. APPLE *Malus species* 62
Seedlings and selection 58
Ancestry of apple selections at the University of Saskatchewan (paper) 64
Field Notes and Data Base 68
Sensory Evaluation of stored Apples 75
Fruit Storage 2001 82
Most Promising Apples 2002 85
Apple Rootstock Selection 86

CHAPTER 6. MISCELLANEOUS FRUITS 89
Pears 89
Plums 90
Sand Cherry (*Prunus besseyi*) 91
Raspberries 92
Grapes 93

EXTENSION ACTIVITIES 94

Events 94

Articles 102
Hardy Sour Cherries: choosing varieties, systems and markets 103
Opportunities for fruit production In Saskatchewan 107
Grower-managed, apple test ochards 112
Testing apples 114
Dwarf Sour Cherry - a two page guide 116
Description of 18-10-32 APPLE 118
Co-operative testing program for new fruit selections 119

RECOMMENDATIONS 123

REFERENCES: 123

List of Figures

Figure 1.1. Seeds planted for the breeding program....10

Figure 1.2. Effect of IBA rooting treatments on five apple cultivars for percent rooted, root number and root dry weight....13

Figure 1.3. Effect of IBA rooting treatments on randomized dwarf sour cherry selections for percent rooted, root number and root dry weight....15

Figure 1.4. Effect of IBA rooting treatments on three selections of double flowered plums for percent rooted, root number and root dry weight....16

Figure 1.5. Effect of IBA rooting treatments and etiolation treatment on hazelnut selection SX88-16 for percent rooted, root number and root dry weight....17

Figure 1.6. Effect of IBA rooting treatments on Nelson seedling saskatoons for percent rooted, root number and root dry weight....18

Figure 2.1. Close-up of SK7-21-16.3 Cherry....32

Figure 2.2. Catch Frame for Dwarf Sour Cherry harvesting....35

Figure 2.3. Fruit retention force, soluble solids, and flesh to pit ratios for advanced selections in 2000....43

Figure 2.4. Soluble Solids and acidity for SK cherries and juices found in grocery stores. 46

Figure 3.1. Photo of Blue Belle....54

Figure 3.2. Photo of Berry Blue....54

Figure 3.3. Yields of Blue Honeysuckles in 2001 and 2002....55

Figure 3.4. Four varieties of Blue honeysuckles (Left to right: Berry Blue, Blue Bird, Blue Belle, Blue Velvet) and fresh Florida blueberries....56

Figure 3.5. Average fruit weight of three varieties in 2002....56

Figure 5.1. Number of apple seedling in various categories for breeding purposes, 1999 to 2002....62

Figure 5.2. Distribution of apple budwood to propagators and co-operators....63

Figure. 5.3. Origin of founders of prairie apples of different eras. Based on Saunders (1911),Patterson (1936, 1960), Ronald (1978) and advanced selections of the University of Saskatchewan fruit-breeding program 63

Figure 6.1. Young tree and fruit of 18-10-32 apple 118

List of Tables

Table 1.1. Best Media for Proliferation of Dwarf Sour Cherry 21

Table 1.2. Rooting media for Dwarf Sour Cherry 22

Table 1.3 Best Strawberry (Fragaria) Proliferation Media 23

Table 1.4. Best Raspberry (Rubus) Proliferation Media 23

Table 1.5. Apple (Malus) Proliferation Media 24

Table 2.1. Dwarf Cherry Evaluations 1999 29

Table 2.2. Ten sour cherry cultivars obtained for the breeding program 33

Table 2.3. Tensiometer readings of 7 sour cherries including ethephon treatments to Carmine Jewel 34

Table 2.4. Lineage of advanced selections 42

Table 2.5. Comparison of advanced selections in 1999 and 2000 43

Table 2.6. Comparison of tree characteristics 52

Table 4.1. Hazelnut evaluations 60

Table 5.1. Founders of recent advanced selections at the University of Saskatchewan. 67

Table 5.2. Intermediate parents of recent advanced selections of the University of Saskatchewan 67

Table 5.3: Field Observations of Apple Seedlings 69

Table 5.4. Brief description of apple selections and cultivars 72

Table 5.5. Best Apple selections after storage, 1999 76

Table 5.6. Penetrometer tests on University of Saskatchewan selection on 18 January 2000 78

Table 5.7. Apple Cultivars and Selections Pressure and Sensory Tests in Storage 2000/2001 79

Table 5.8 Fresh apple score sheet 83

Table 5.9. Results of fresh apple evaluations, Fall 2001 84

Table 5.10. Most Promising Apples, 2002 85

Table 5.11. Promising apple rootstock selections from hardwood cuttings that rooted in storage 86

Table 5.12. Observations on winter injury on V series rootstock, spring and summer of 2002 88

Table 6.1 Comparison of key attributes of a few fruit crops 110

INTRODUCTION

PROJECT SUMMARY

The fruit breeding program at the University of Saskatchewan has been ongoing since Cecil Patterson started it in the 1920's. At the beginning it was not possible to grow fruit crops of good quality in Saskatchewan. Cold hardy species had to be introgressed into cultivars, which required further generations to improve fruit quality since wild species are notoriously inferior. Steady improvement was made on a number of crops, and each generation has shown improvements over earlier cultivars. As fruit crops often require seven years or so per breeding cycle, progress was inherently slow but progress was steady. Other institutions on the prairies, which had been breeding fruit crops (i.e. Morden Research Station, Manitoba) closed down their fruit breeding programs. This left the University of Saskatchewan's fruit breeding program as the only public source for new fruit varieties adapted to the prairie conditions.

Today, there are many exciting developments, which are the culmination of decades of breeding activity and working with growers. We have cold hardy apple cultivars with fruit quality that rivals other North American cultivars and several commercial apple orchards are coming into production. Two recently released cold hardy raspberry cultivars have major improvements over older cold hardy varieties. Interesting improvements are being made with hazelnuts, and strawberries are being introgressed with unique germplasm from Asia and Europe. Progress with dwarf sour cherries has also been remarkable.

In this project, a large percentage of the research was on dwarf sour cherries. The decision to emphasise this crop was based on many factors including:

1. The dwarf sour cherries, are a hybrid species and are unique in the world of cherry breeding. Thus, there is a need to develop management and harvesting technology for growers.
2. There appears to be a great lack of cherry products in the marketplace
3. Dwarf sour cherries are relatively disease and pest free and are cold hardy.
4. Their harvest season occurs just after saskatoon harvest but before apples or most grain crops. Thus, they could easily fit into the schedule of farmers with diversified crops.
5. Dwarf Sour Cherries have potential for automated harvesting.
6. Many of the selections of Dwarf Sour Cherries are quite sweet and are not really very sour. There may be potential in the fresh market and in a variety of products for our cherries.

The University has over 50 promising selections of apples, which are being distributed for trial by growers. Much of this portion of the project deals with extension activities and evaluation of fruit quality. Interest in apple production has been grower driven with many growers primarily interested in them for pick-your-own or local markets. The apples being tested by the U of S are a significant improvement over older prairie cultivars for size, firmness and longer shelf life. Apples are key components of many fruit products such as juice and fruit leathers and could be useful in combining with saskatoons or cherries in secondary processing. Although there is a glut of fresh apples on the global market, organic apples are rare and in demand could make inroads to this market. Fortunately the climatic conditions of Saskatchewan greatly inhibit the pests and diseases of apples making organic production feasible. Growers that do not have organic production should consider secondary processing or local markets as the major outlet for sales of apples.

The Domestic Fruit Development Program also deals on a limited basis with a variety of fruit crops including: blue honeysuckles, raspberries, hazelnuts, sand cherries, cherry plums, plums, pears, and black currents. In many ways the University is acting as a prairie repository for these cold hardy fruits. Breeding occurs with these crops on a rotating basis every few years with the progeny sent to co-operating growers or kept at the University plots. In this way, continued improvement can occur at minimal cost. Many of these projects are long term and require several generations of improvements. However, the quality of some of these crops is approaching commercial standards and will likely receive greater emphasis in the future.

Extension has become an increasingly important component of the program, as many growers contacting us are grain farmers seeking to diversify their production. As the program has been receiving favourable press, radio and TV interviews, so have the number of calls and letters from farmers increased. Our general strategy to handle this influx of interest is to encourage interested farmers to join the Saskatchewan Fruit Growers Association and then to make ourselves available for lectures and workshops organized by the SFGA and SAF Extension Agrologists. Although this 'increase' in extension activities may seem to detract from research, it in fact frees time up for research. It is much easier to tell many farmers to attend an upcoming event than it is to have long telephone conversations with each farmer.

Extension activities included several speaking engagements, workshops, writing of articles, setting up displays at shows, and website development.

Project Summary, December 2002

There were more extension activities than last year including workshops, field days and The Alberta Horticultural Congress in Edmonton. Many more growers contacted us to inquire about establishing domestic fruit orchards. This was due to word of mouth and the good publicity that this project received in both Saskatchewan and Alberta. Samples of our apple selections were provided (on request) for apple tasting in Alberta. There was also an increase in the number of apple buds that we distributed in August. The apple rootstock selections were propagated and distributed to grower test sites including one in the Yukon owned by John Lenart. Growers planted 15,0000 cherry seeds at the Horticulture Field Lab this fall on three dates.

Cherry and Blue Honeysuckle orchards received priority planting in the Horticulture plots, while the apple and pear seedlings were kept in the shade house for planting next year. Due to lack of funding, the essential fall field work was very late in being finished but was completed before the end of November.

On October 17 small plants of twelve new honeysuckle clones arrived from Russia's Vavilov Institute. These are a valuable contribution to the development of this important fruit crop new to Canada.

PROJECT PERSONNEL

The first year of this project, Bob Bors, Assistant Professor the Plant Sciences Department and Karen Tanino Associate Professor coordinated the activities of the program. At the end of 1999 Karen Tanino stepped down and Bob Bors was made head of the project. Rick Sawatzky, Tech IV, was the chief technician of the project providing. Bob, Karen and Rick's positions were funded by the University of Saskatchewan and their participation in the project was in kind support. ADF provided funds to hire Forrest Scharf as a half time Tech I. Forrest Scarf works the other half of his time on ADF#19990319-42BX 'Incorporating Disease Resistance and developing guidelines for disease-free certification for Saskatchewan Strawberry plants'. Funding allowed the hiring of 2 half-time summer students through the 4 seasons of this project. These summer students were: Heather Hack, Heather Drysdale, Megan Payne, Nathan Dzialo, Dale Murray and Jie Qiu.

In addition to the above, University undergraduate students, Heather Drysdale and Megan Payne, did thesis projects involving fruit experiments. We had assistance from over 25 growers who donated time to the project. Graduate student Qiuju Lu and Shiming Xue assisted with pollination, seeding, workshops and planting activities.

PROJECT GOALS

Identify/develop/select new domestic fruit cultivars for the Saskatchewan climate and develop effective cultural practices and propagation methods for both the fruit and nursery Industries *and communicate these methods to the industry*. These include:

1. Selection, screening, and quality evaluations
2. Distribution
3. Test marketing, promotion, and extension
4. Cultivar releases
5. Cultural practices
6. Development of propagation protocols

RESEARCH SECTION

Chapter 1. PROPAGATION

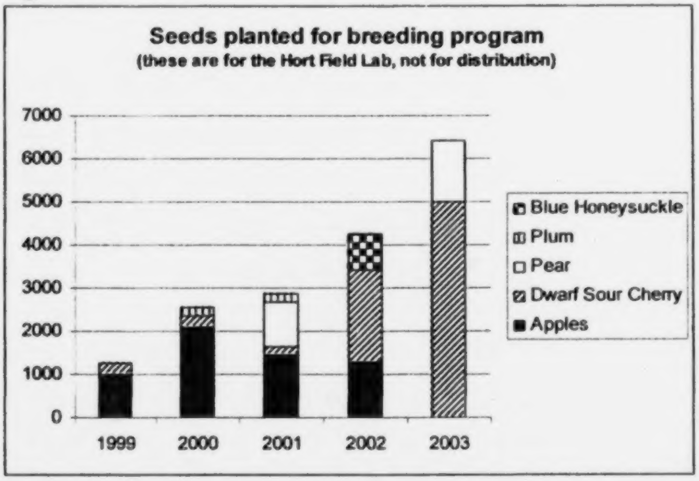
Seedlings germinated for Fruit Breeding

17,371 seedlings were planted as breeding material for our plots at the Horticulture Field lab. All of these required special conditions of stratification and refrigeration and were grown using protective conditions in the greenhouse, mist bed or shade house. A few rows of direct field planting were attempted with plums and sour cherries but less than 5% of seeds germinated. Table 1 shows the increasing trend that was made possible by increased number of man hours donated by co-operators. The strategy in this program is to concentrate on a few crops in any given year and to rotate breeding efforts. More apples were planted in the early years of the project while more Dwarf Sour Cherries were planted in recent years. The Apples and Sour Cherries planted during this project will provide a sizable germplasm base for selection 7 to 10 years in the future.

An additional 37,478 seeds were planted for distribution to growers. Growers themselves planted most of these seeds. 35,000 of these seeds were Dwarf Sour Cherries. Co-operators receiving our seedlings sign an agreement that allows the U. of Saskatchewan to retain rights to any new potential varieties. Growers are allowed to use the fruit of the seedlings and may propagate the best seedlings for their own use.

Many breeding programs focusing on tree fruits typically plant 2000 or less seedlings a year. This program averaged over 12,000 seedlings per year!

Figure 1.1.



Note: The numbers for 2003 represent seeds planted in flats undergoing stratification for germination in spring of 2003.

Testing of three hormone preparations on juvenile cuttings of Ottawa-3 apples, Dwarf Sour cherries, Hazelnuts, double-flowered plums, and saskatoons.

Introduction:

The plants used in this experiment are considered difficult to root. However, many nurseries do not recognize the value of using juvenile material despite the fact that research has occurred. This experiment investigates the influence of various hormone treatments using juvenile material. This experiment was done by a summer student, Heather Hack.

Materials and methods

This experiment was conducted to compare the rooting of three different rooting hormones for apples, hazelnuts, cherries, saskatoons, and double flowering plums. The rooting hormones used were two commonly used commercial preparations- Stim-Root Powder No.3 (0.8% IBA), and Stim-Root liquid 10000 (1.0% IBA), and a rooting hormone developed at by Rick Sawatzky at the University of Saskatchewan - Jungle Dip (2.0% IBA, plus other chemicals, potential patent application). Commercial preparations were purchased from Plant Products Co. Ltd., Brampton, ON. Controls, having no rooting hormones, were also included in the experiment. The lower 1 cm of each cutting was dipped into rooting hormones.

An important component of this study was to use juvenile sources for cuttings (i.e. shoots coming from the base of trees, rather than the tops). Most of the crops in this study are considered difficult to propagate. The apple rootstock, non-etiolated hazelnuts, cherries, saskatoons, and double flowering plums were cut down in spring and allowed to grow back for four to five weeks to reach a height of approx. 20 cm. Once this height was reached, the cuttings were taken from the field and brought in for treatment. Proper measures were taken to ensure that the cuttings did no get too hot to avoid wilting. Forty cuttings were taken each species for one rep for most species. Ten cuttings per rep were treated with either 0, 0.8, 1.0 or 2.0% IBA. However, double flowering plums (tree one and three) had only 5 cuttings per treatment. For this experiment, cuttings were taken from June 30th to July 12th.

Half of the hazelnuts were etiolated before they were harvested. These were cut down in the spring and then covered with the etiolating tunnel. This tunnel consisted of wire hoops covered with black polyethylene plastic covered with soil on the sides and stakes on the end to hold it down. Pipes were also inserted on the north side on the ground level and a little higher up for ventilation. The plants were allowed to grow back under the tunnel for around three to four weeks. Slits were then cut in the plastic to allow the cuttings to re-green for the final week of the growing. When the cuttings had reached around 20 cm, they were used as cuttings.

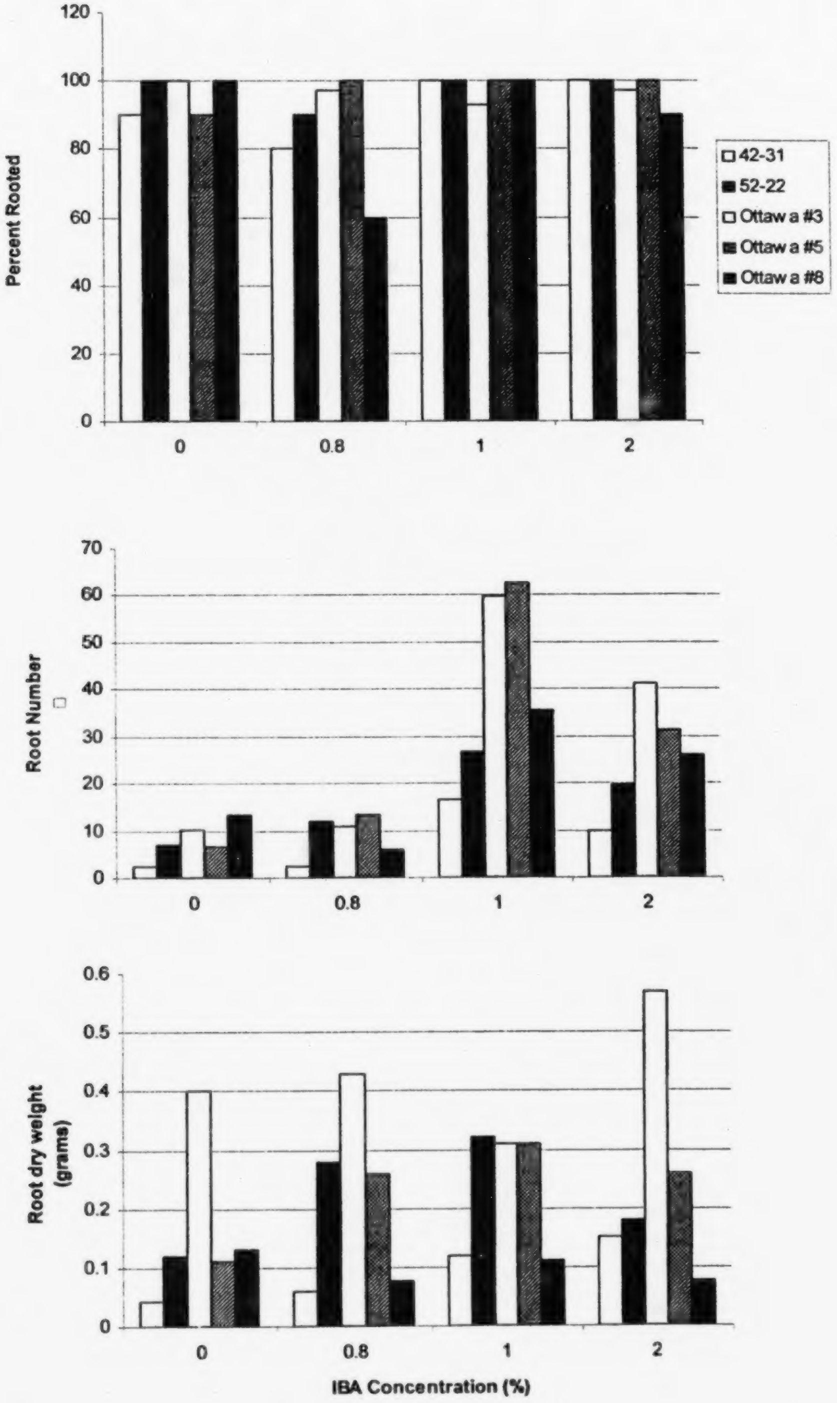
The leaves on the bottom two-thirds of each shoot were removed from cuttings to reduce transpiration loss. The cuttings were left the same height as when cut from the field and not cut in half to obtain the same height. This was done because this tissue is more juvenile and easier to root since cuttings were not the same lengths they were randomized so each treatment had a similar range of heights. Immediately before dipping with the rooting hormones, the ends of cuttings were trimmed off to supply a fresh cut surface. Cuttings were placed in styro-blocks containing Sunshine Mix #4 media placed under an outdoor mist system and fertilized once with 28-14-14 on Aug 12. Cuttings were allowed to grow for the entire growing season. Plants were harvested on September 20th so that data could be taken. Percent rooting, number of roots/plant, and root dry weight were analyzed for each plant.

Results and Discussion

Apples (see Figure 1.2):

Percent rooting was similar for all treatments, including controls. Root number was highest for 1% IBA. The 42-31 and Ottawa 3 genotypes had higher root dry weight with 2% IBA but the other three genotypes had higher root dry weight with1% IBA. It is interesting that Ottawa 3 did so well compared to other genotypes it has a reputation for being a difficult rootstock to propagate. Our success in this is likely due to our source of Ottawa 3. Our O.3 stock was brought here by Dr. S. Nelson (one of its developers) and he took care to ensure that juvenile material was used for our stock material. Rick Sawatzky has maintained this in strict adherence to Nelson 1976 and 1978.

Figure 1.2. Effect of IBA rooting treatments on five apple cultivars for percent rooted, root number and root dry weight.



Cherries (see Figure 1.3):

The dwarf sour cherries had higher percent rooting and greater dry weights when no hormones were applied, although 1% IBA was the best treatment for root production. It is encouraging that these cherries are easily propagated.

Doubled flowered plums (see Figure 1.4)

A great deal of variation was seen in the three genotypes in the control with less differences between them at 2% IBA. While more roots were produced with 2% IBA it may be optimum to propagate trees 1 and 2 with 0.8% IBA since this gave the highest root dry weight. Clearly, 2.0% IBA is the best treatment for tree 3.

Hazelnuts (See Figure 1.5)

An interesting interaction occurred between etiolation and hormone treatments for all three characters measured. With controls, percent rooting was highest with non-etiolated cuttings. At 0.8% IBA, the effect of etiolation was minimal, but at 1 or 2% IBA etiolated cuttings were superior. Optimum treatment combination was non-etiolated cuttings with 0.8% IBA.

Saskatoons (See Figure 1.6)

Although 1% IBA gave significantly higher numbers of roots, percent rooted and root dry weight were very similar for all treatments.

General conclusions

It is particularly notable that percent rooted of control plants was often similar to the hormone treatments. Although Control plants did not have as many roots, root dry weight was often similar to hormone treatments. This indicates compensation occurs whereby plants with fewer roots have longer roots. The control plants doing well in all experiments indicate that the methodology for taking and using cuttings are the most important factors in obtaining rooted cuttings and that smaller improvements can be achieved when hormones are used. Genotypes were important factors in the two studies that had different genotypes. It seems reasonable to expect that genotypes could play an important role in cherries, hazelnuts and saskatoons, although genotypes were not tested for these crops. It may be worthwhile to investigate and optimize rooting treatments for new fruit cultivars released by the program.

Figure 1.3. Effect of IBA rooting treatments on randomized dwarf sour cherry selections for percent rooted, root number and root dry weight.

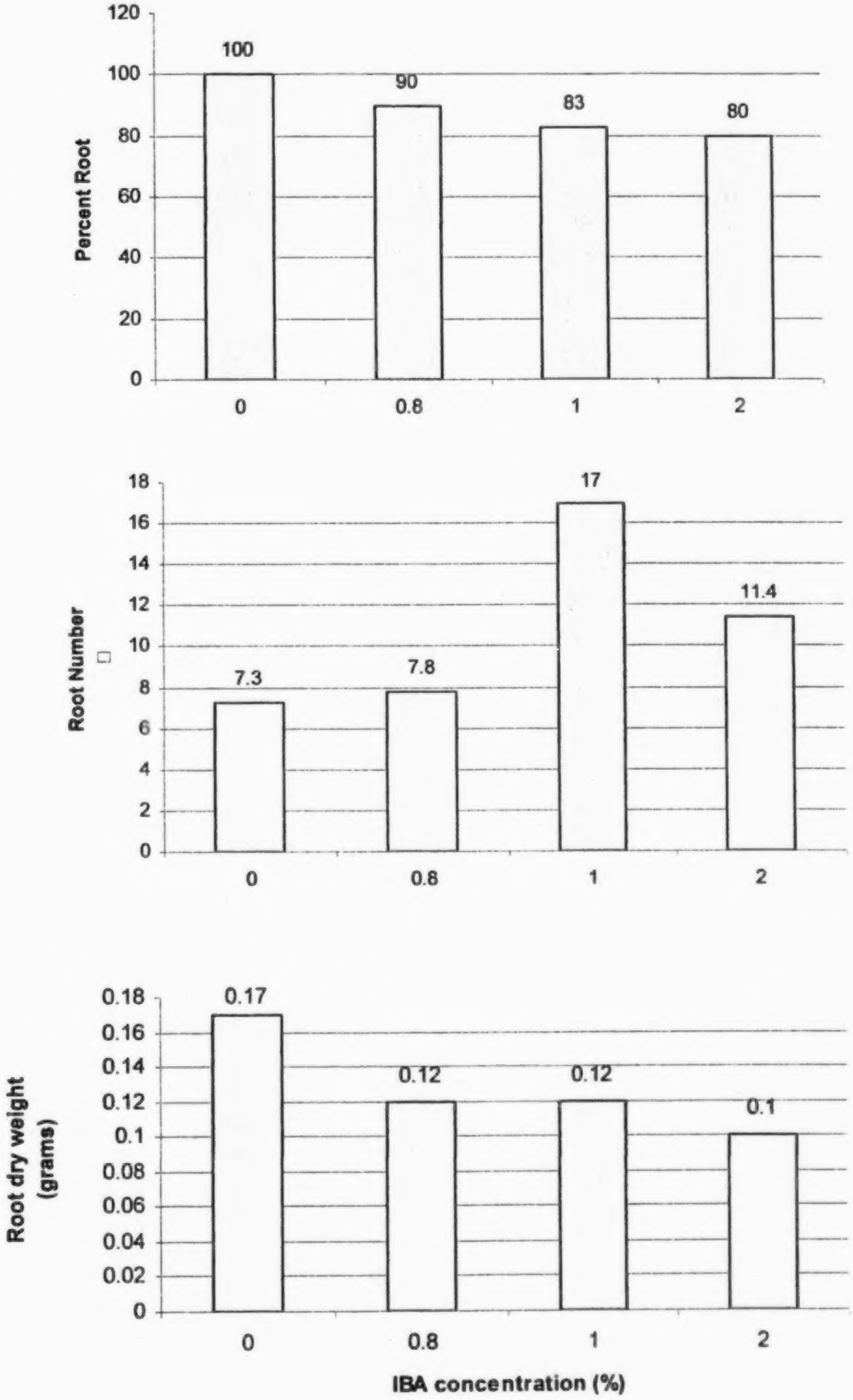


Figure 1.4. Effect of IBA rooting treatments on three selections of double flowered plums for percent rooted, root number and root dry weight.

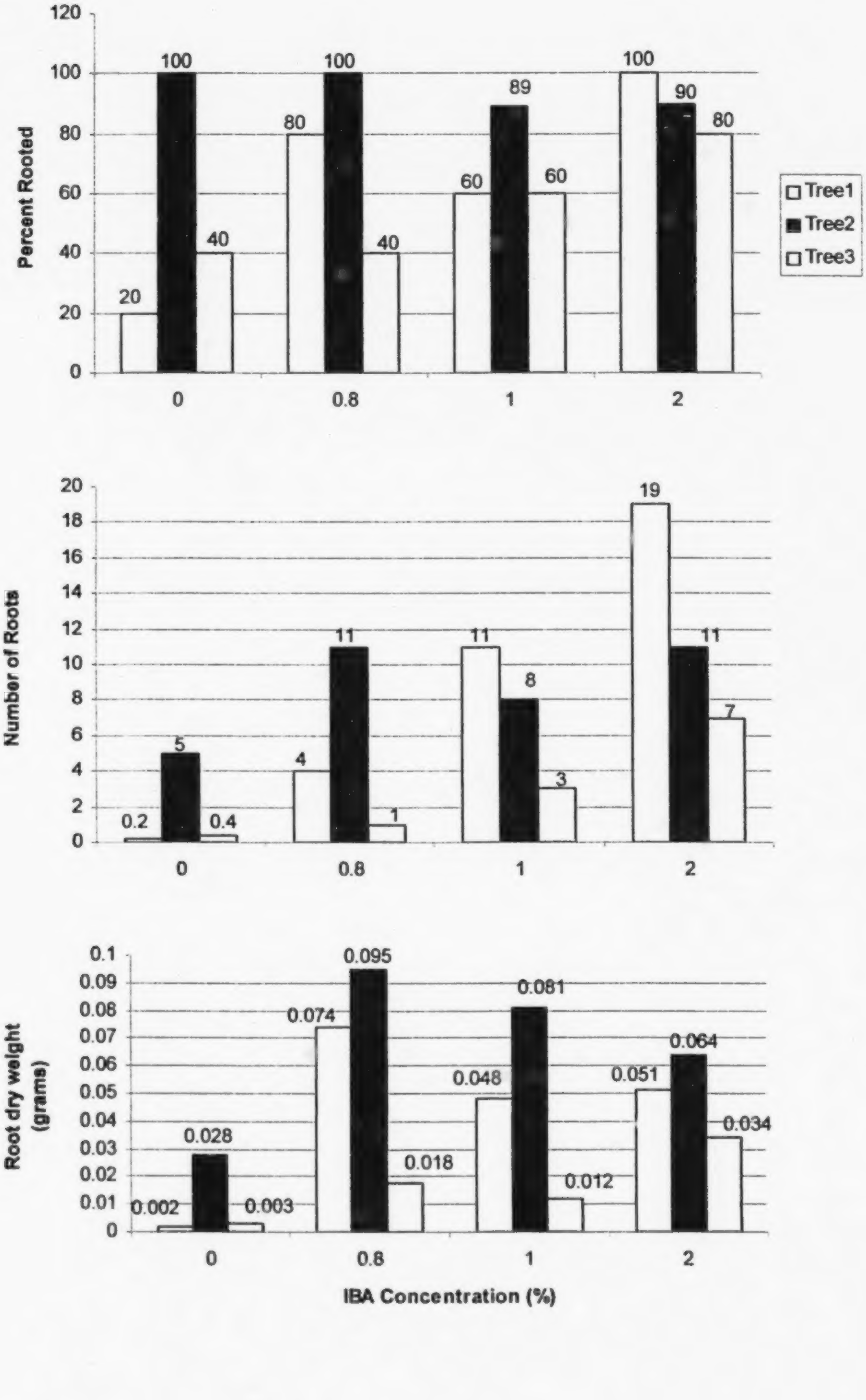


Figure 1.5. Effect of IBA rooting treatments and etiolation treatment on hazelnut selection SX88-16 for percent rooted, root number and root dry weight.

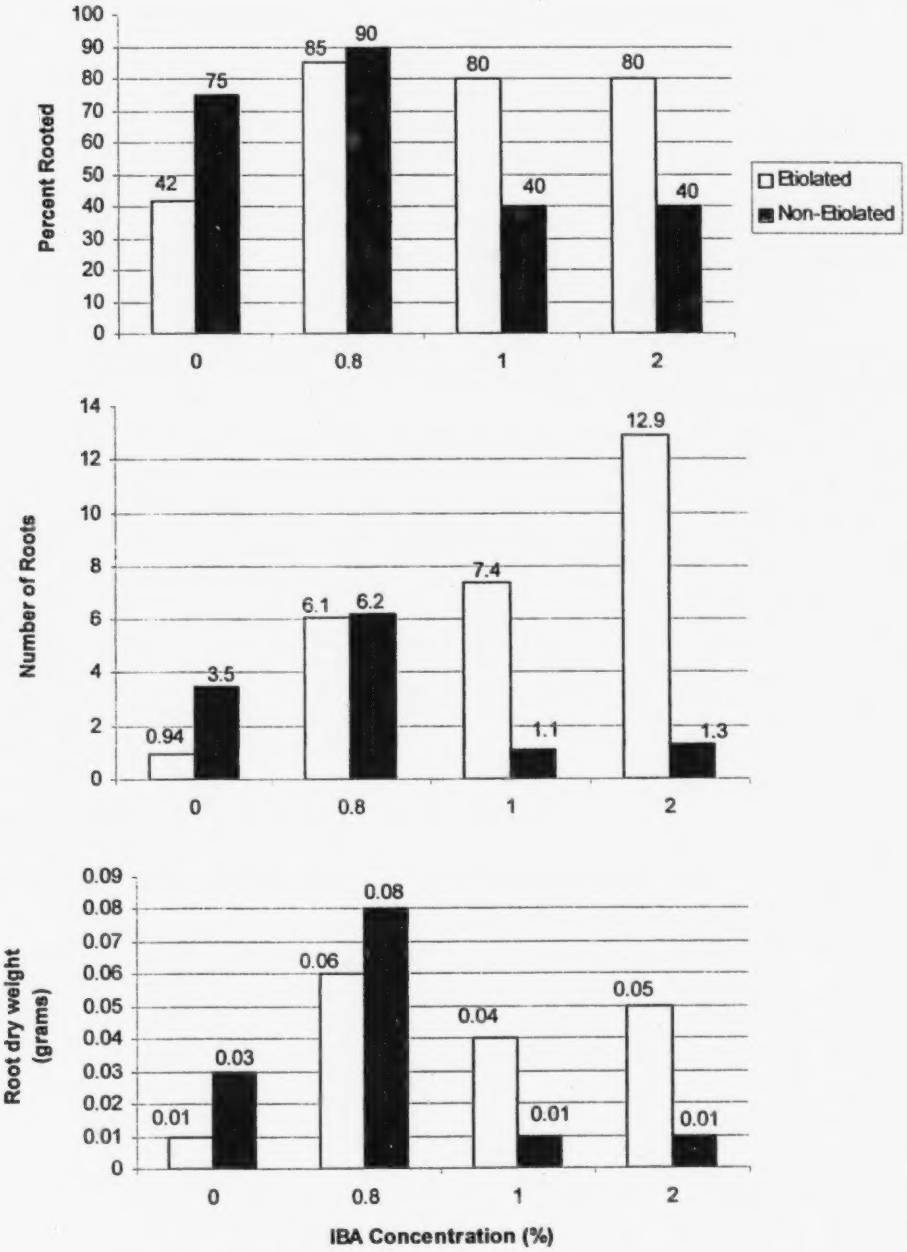
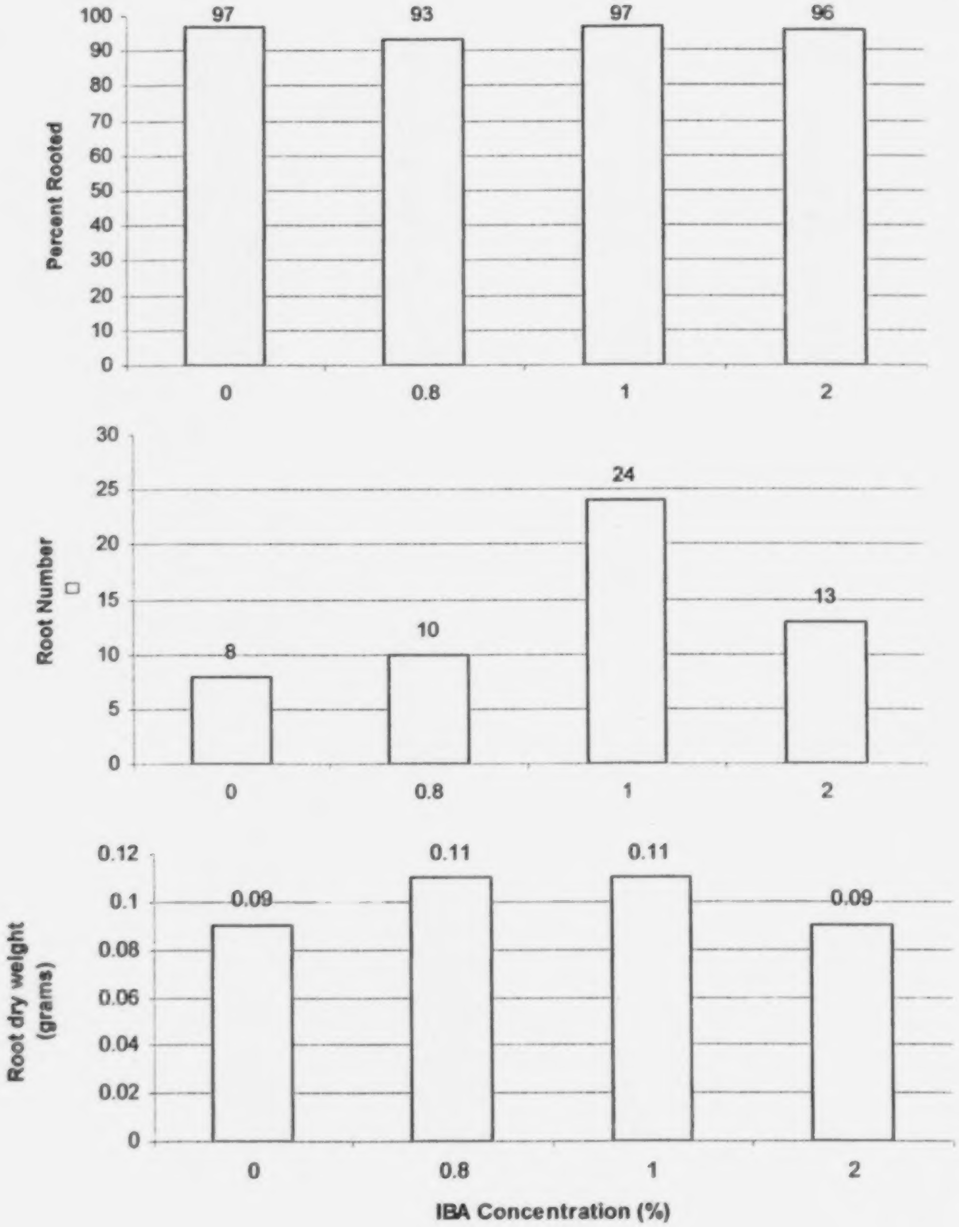


Figure 1.6. Effect of IBA rooting treatments on Nelson seedling saskatoons for percent rooted, root number and root dry weight.



Hardwood Cuttings of Ottawa 3

Ottawa 3 (O3) is the dwarfing rootstock for apples dwarfing rootstock recommended for the Prairie. As stock beds of O3 are cut to the ground in early spring, it seemed a worthwhile idea to investigate propagation with hardwood cuttings. If successful, A propagator could double the production of rootstock by having a winter crop.

An experiment was initiated involving Bob Bors and two students Linda Matthews and Nathan Dzialo. Hardwood cuttings were taken of Ottawa 3 (dwarfing apple rootstock), a dwarf sour cherry seedling and a rare interspecific hybrid cherry. These cuttings were treated with rooting compound and placed in different environments over the winter. Results on this experiment will not be known until early summer. Softwood cuttings would be the normal method of propagation for these trees, but if hardwood cuttings would work, it might be possible for nurserymen to double cutting production. Hardwood cuttings are not anything new, but details for prairie conditions and these particular varieties would be useful to fruit nurserymen.

Results:
The experiment was not particularly successful. Linda Matthew had some rooting of her cuttings, which she had over wintered outside. The other two sets of cuttings had been stored in refrigerators and did not root. However, by the time Linda's cuttings had rooted, the softwood cuttings from the following season had rooted. Thus, there was no advantage in taking the cuttings early in the fall.

Parafilm wrap for grafting

The use of parafilm as a wrap/sealant in the bud-grafting propagation procedure has been working very well. Although the small test done last fall comparing the use of parafilm with the use of rubber budding strips was not large enough to be analyzed statistically, it appears as though parafilm is at least as useful as rubber strips. The test suggested that parafilm may be less attractive to the magpies and it is definitely more convenient to use on larger rootstock. It is more easily used by beginners and many co-operators have seen these benefits and are using it. Qiuju Lu, a graduate student, first showed us this technique which had been in use in China for commercial operations.

Apple Cultivar Conversion Experiment

The Apple Cultivar Conversion Experiment at Yoanna Nurseries and Orchards in 2001/2002 was designed to investigate methods of converting established apple trees on Ottawa #3 dwarfing rootstock from one fruiting cultivar to another. Converting trees removes the need to pull out trees of an outdated cultivar and plant young trees of the new cultivar. Converting trees to new cultivars may be quicker than starting new trees.

The key is to avoid the high establishment and maintenance costs associated with converted trees. The timing and treatments were designed to accomplish this. The treatments were done in late fall (November) when time permitted. All trees were cut off at the soil line so that only one or two grafts would be necessary to re-establish the tree. Root pruning was done at two depths to prevent high maintenance costs associated with excessive sucker growth. Checks were included.
The test plot itself (two rows located in the middle of the orchard) was severely winter-killed compared to the rest of the orchard Severe fall pruning of trees on Ottawa #3 dwarfing rootstock compromises their winter survival under conditions of severe drought and little snow cover. Treatments that were done in spring, although a much busier time of year, and under moist conditions may be more successful.

Propagation of Dwarf Sour Cherries

The major bottleneck for dwarf sour cherry production in Saskatchewan has been propagation. The primary propagator of SK Carmine Jewel expressed concern that demand far outstrips supply. A series of propagation experiments began in 2001 to overcome this problem.

Cuttings

Over a 3 year period, cuttings have been taken in early June, early August, mid August, and in the greenhouse during winter. Most experiments tested five advanced and/or SK Carmine Jewel.

Rooting occurred on all dates in the summer. Winter rooting was more problematic as stock plants and newly rooted cuttings often went dormant and would no longer produce good shoot growth. Greenhouse rooting was further enhanced by providing bottom heat.

The cherries propagated in 2001 were placed in mist beds set for ideal conditions for apple rootstock. They seemed to be more susceptible to rots, which indicate a few areas that could be investigated:

1. a lower frequency of misting is needed.
2. a potting mix with less water holding capacity (perhaps sand mixture?)
3. fungicides are needed

Various experiments were done using IBA and IBA + NAA, and various concentrations of these but no treatment seemed superior. IBA powder #2 was the control in most cases and usually gave >80% rooting.

Seed germination

Cherry seeds were stratified immediately after harvest and distributed to 4 co-operating growers as well as being germinated at the U of S in 2001/2002. The data from this experiment indicates that sour cherry seedlings vary tremendously in amount of time needed to overcome dormancy. Rather than having a specific time for germination, it appears that more seedlings will germinate the longer the seeds are kept in cold storage. It seems unlikely that seed distribution to growers will be a viable option, as it will require biweekly checking and planting of seeds. More research will be needed to attempt to synchronise germination. Perhaps drying of seeds or adding a cyclical freeze to the stratification treatment could be used to cause greater uniformity in germination.

This experiment allowed us to get a head start on propagation of seedlings for our breeding program. Approximately 2000 trees have been grown in the greenhouse, many of which are over a foot tall. For these early germinated trees, it is likely that they will be able to fruit a year earlier than the way we had previously germinated trees outside during the summer.

Tissue Culture

Dwarf sour cherry:

At the start of this grant it was impossible for us to propagate dwarf sour cherries. Many attempts were made during 1999 and 2000 that failed. Poor results were occurring for DNA Gardens who was attempting to proliferate SK Carmine Jewel. It became apparent that if Dwarf Sour Cherries were to be produced in quantities needed for commercial production that we would have to develop protocols and media recipes. After a thorough lit search, a key paper was found that investigated various agars. When we switched to Agar-Agar (Sigma A-9915) in 2001 we were able for the first time to proliferate sour cherries in vitro. What followed was 2 years of tweaking various components (mainly hormones), the results of which follow. This research is being used by 6 tissue culture companies who will be selling our varieties in 2003.

Table 1.1. Best Media for Proliferation of Dwarf Sour Cherry:

4.4	g/l	MS salts
100	mg/l	ADS (Adenine)
100	mg/l	myo-Inositol (can leave out?)
10	mg/l	NaH_2PO_4
1	mg/l	Thiamine
1	mg/l	Nicotinic Acid
1	mg/l	Pyridoxine
2	mg/l	Glycine
1	mg/l	BAP (6-Benzylaminopurine)
0.1	mg/l	GA_3 (Gibberellic Acid)
1	mg/l	IBA (Indole-3-Butyric Acid)
30	g/l	Sucrose (Sugar)
7	g/l	Agar-Agar (Sigma A-9915)*

adjust pH to 5.7

* it is very important to use precisely this type of agar

Variations tested:

Same as above except 0 BAP = slow response, very poor proliferation, (root initials developing?)

Same except 0.35 mg/l BAP = poor proliferation, weak response, poor proliferation

Same except 0.7 mg/l BAP = poor proliferation, more woody type growth, (greener leaf tissue?)

Same except 300/l mg $Ca(NO_3)_2$ = tip burning, stunted growth

Same except 2 mg/l 2ip = somewhat variable response, growth not as strong, (some callus development?)

Same except 250mg/l $Ca(NO_3)_2$ + 1 mg 2ip = tip burn, poor proliferation

Same except 0.2 mg/l GA_3 + 1 mg/l 2ip = variable response, 7-7-5.8 (better?), 7-21-16.3 (poor?), (callus developing on leaves?)

Same except 10 mg/l Thiamine = more shoot proliferation, fewer strong shoots

Same except delete 100 mg/l Myo-Inositol = (greener leaf tissue?), more woody growth

Same except substitute B5 salts = consistent poor growth response, seem to lack vigour (lack nutrients?)

Table 1.2. Rooting media for Dwarf Sour Cherry:

2.2	g/l	MS salts
100	mg/l	ADS
100	mg/l	myo-Inositol
10	mg/l	NaH_2PO_4
1	mg/l	Thiamine
1	mg/l	Nicotinic Acid
1	mg/l	Pyridoxine
2	mg/l	Glycine
0.5	mg/l	NAA (α- Naphthalene-Acetic Acid)
0.25	mg/l	IBA
30	g/l	Sucrose
7	g/l	Agar-Agar (Sigma A-9915)

adjust pH to 5.7

Variations Tested:

Same as above except no IBA = rooting slower (less vigorous), fewer root hairs

Same as above except 1 mg/l IBA + no NAA = slow growing thin woody roots

Same as above except 0.25 mg/l NAA + 0.5 mg/l IBA= slow initiation, thin roots

Same as above except B5 salt = high death rate, (lack nutrients)

Same as above except 125 mg/l $Ca(NO_3)_2$ = some leaf burn (rooting hindered?)

Strawberry

Table 1.3 Best Strawberry (Fragaria) Proliferation Media:

4.4	g/l	MS salts
100	mg/l	ADS
10	mg/l	NaH_2PO_4
0.5	mg/l	Thiamine
0.5	mg/l	Nicotinic Acid
0.5	mg/l	Pyrodoxine
1	mg/l	BAP (BA)
30	g/l	Sucrose
7	g/l	Agar-Agar
2	g/l	Charcoal (Activated)

Note: pH adjusted to 5.7

Variations tested:

Same as above except 23.21 g/l B5 salts + 2 mg/l glycine = lack of proliferation
Variable levels of chlorosis
Same as above except 100 mg/l Myo-Inositol = some chlorosis
Same as above except 20 mg/l NaH_2PO_4 = larger leaves, less proliferation
Same as above except 1.5 g/l charcoal = variable response (some species poor)
Same as above except 3 g/l charcoal = poor proliferation (some chlorosis)
General comment: Need better proliferation! (Change hormone?)

Raspberry

Table 1.4. Best Raspberry (Rubus) Proliferation Media:

4.4	g/l	MS salts
100	mg/l	myo-Inositol
0.4	mg/l	Thiamine
1	mg/l	BAP (BA)
0.1	mg/l	GA_3
0.1	mg/l	IBA
30	g/l	Sucrose
7	g/l	Agar-Agar

Note: pH adjusted to 5.5

Variations Tested:

Same as above except 23.21 g/l B5 salts used = tissue blackens at media contact,
poor proliferation, slow leaf death
Same as above except 3.5 g/l phytagel = high death rate, poor proliferation
Same as above except 1 mg/l IBA = callus blackens, poor growth & proliferation

General comment: Needs more work to improve vigour & eventually develop rooting protocol.

Apple

Table 1.5. Apple (Malus) Proliferation Media:

4.4	g/l	MS salts
200	mg/l	myo-Inositol
5	mg/l	Glycine
2.5	mg/l	Thiamine
1.0	mg/l	Nicotinamide
1.0	mg/l	Pyridoxine
25	mg/l	Thiourea
180	mg/l	Asparagine
30	mg/l	$FeSO_4$ (Ferrous Sulfate)
1	mg/l	BAP
1	mg/l	IBA
0.1	mg/l	GA_3
30	g/l	Sucrose
7	g/l	Agar-Agar

Note: pH adjusted to 5.7

Variations tested:

Same as above except Bacto Agar used = lack of good gelling characteristics, death, lack of proliferation response
Same as above except 4 mg/l Thiamine = tip growth stunted, leaf edge burning
Same as above except 100mg/l Myo-inositol = pale leaves/chlorosis

We only used the Ottawa-3 variety with these experiments. The media developed is a vast improvement over the Ag-Canada formula from which it was partially derived.

A small experiment was conducted on the pH of media after plantlets had been growing in it for 3 weeks. The pH of media that was associated with vigorous healthy plant growth, dropped from initial pH 5.7 to approximately pH 4.2 (on average). The pH of the media that was associated with poor growth characteristics, increased from pH 5.7 to pH 7.0.

Tissue culture of apple rootstocks, April 2002

Ottawa 3 rootstock shoot tissue was obtained from rooted cuttings taken from the field. The rooted cuttings had been subjected to a vernalization period. When they were brought out of their cooling treatment, the top growth was removed in order to initiate new shoot development. When sufficient growth was available, 2/3 of the shoot was removed for tissue culture work.

The apples were placed in a media derived from the recommendations of Pua, Chong, and Rouselle (Can J. Plant Sci. 63: 183-188).

The media included: 4.4 g/l MS medium; 30mg/l $FeNa_2EDTA$; 25 mg/l Thiourea; 180 mg/l asparagine; 2.0 mg/l Glycine; 0.1 mg/l thiamin•HCL; 0.5 mg/l pyridoxin•HCL; 0.5 mg/l nicotinic acid; 0.5 mg/l NAA; 0.5 mg/l BAP; 5.0 mg/l gibberellic acid; 100 mg/l inositol; 30g/l sucrose; 7 g/l Difco-Bacto agar. The pH was adjusted to 5.7.

The apples are growing in the media at present and seem to be responding well.

There are presently 210 plantlets in culture.

Chapter 2. DWARF SOUR CHERRIES

Germplasm Development and Breeding

Progress in the area of sour cherry breeding has been particularly remarkable. Not only has cold hardiness has been introgressed from *P. fruticosa* into sour cherries *(Prunus cerasus)*, but the resulting hybrids are dwarf! Cherry breeders from around the world have been attempting to develop dwarf cherry rootstocks but graft incompatibility has been a persistent problem (Claussen, 1998). Since the dwarf sour cherries at the U. of Sask. are on their own roots, there is no graft compatibility problem. The U. of Sask. selections are truly unique. Dwarf stature in fruit trees decreases harvesting costs and allows higher density planting which increases yields. The development of dwarf cherries presents interesting challenges as cultural and training practices need to be developed for this new crop.

The purpose of this evaluation was to determine which of the sour cherry seedlings may be suitable for testing by co-operators and eventual release as cultivars. Several hundred Dwarf Sour Cherry seedlings were evaluated in the field and field notes were taken. The most productive of these were more extensively evaluated (see Table 1). The seedlings in Table 1 were studied according to 10 criterion. Each data point in Table 1 is based on 50 cherries, except for qualitative traits.

Important standards in this study are the two newly released cherry cultivars on the market: our own SK Carmine Jewel and Alberta=s Evans Cherry. Only limited numbers of Evans cherries were available so not all tests could be performed on this cultivar.

Selection criterion and measurements:

Average fruit size was further evaluated by looking at its components of flesh/cherry and pit weight. The minimal standard was that average fruit size had to be at least as great as the already released cultivar SK Carmine Jewel.

Soluble Solids was measured in Brix. Again, a value at least as high as SK Carmine Jewel was considered acceptable. It was noted that the two cultivars of cherries, Evans and SK Carmine Jewel, had relatively low levels of sugars compared to the most of the seedlings

Thawed weight retention: As sour cherries are often frozen, the amount of liquid retained after thawing is an indication of how well suited these varieties are for processing. The population of sour cherries as a whole had similar values averaging 63% retention. This was much higher than the 41% retention of the Evans cherry.

Percent Crack Resistant: Cherries were soaked for 24 hours in a volume of deionized water equal to the weight of the cherries. This test is important since years where drought is followed by too much rain, cracked fruit can result. It is likely that high sugar levels are correlated to cracking. The test performed was much more severe than what would occur in nature. A year where cracking occurs in the field will be needed to determine if these numbers can be used to estimate natural cracking.

Percent Rot Resistant This test held cherries at room temperature under high humidity for 4 days after harvest. It was noted that SK Carmine Jewel was exceptionally rot resistant since none of its fruit rotted during the 4 day period. On average, most accessions had 79% rot resistance.

Colour: Fruit colour was categorised as: light, light-medium, medium, medium-dark, or dark. Light colour is best for pies. Dark colour is preferred for juice and processing into dairy products since the darker juice adds more intense colours.

Pit shape: Only round shaped pits would be acceptable for cultivar release. Elongated pits and to a lesser degree, oval pits are more difficult to remove using cherry pitting equipment. It was noted that the Evan=s cherry was totally unacceptable in this regard and as a result will probably never be used on a commercial scale.

Fresh Flavour: It is likely that only the flavour categories Good or Sour would be commercial acceptable. The former category might be acceptable for fresh eating while the later would be good for processing.

Results

Results of cherry evaluations are shown in Table 2.1 with exceptional seedlings highlighted in bold.

Accession **7-21-16.3** seems to have the greatest potential since it has the largest sized fruit, one of the highest soluble solids content, the highest thawed weight retention, round pits, and good flavour. It does have the worst rating for crack resistance, so this trait will have to be watched. The fruit of this accession is almost 50% larger than the two cultivars varieties currently available for the prairies, Carmine Jewel and Evans cultivars. **7-21-16.3** has 21% larger fruit size and is 55% sweeter (soluble solids) than Montmorency, the leading North American cultivar (80% of acreage). The fruit quality of **7-21-16.3** is comparable to selections being tested by Michigan State University (Iezzoni and Karle, 1998). This accession will be propagated in 2000 for larger scale testing in 2001.

Accession **7-21-31.0** also has many good traits, and is similar to SK Carmine Jewel in fruit size and appearance. It is not as large as **7-21-16.3**. This accession will be watched to see if some other worthwhile trait could make it worth releasing. This accession will be propagated in 2000 for larger scale testing in 2001.

SK Carmine Jewel: Although not as remarkable in size or sweetness than the above two selections, SK Carmine Jewel fruit has better crack resistance and better shelf life. It was noted that Carmine jewel was the first cherry to ripen in 1999. Its season went from mid July to mid August while other selections= seasons were throughout August.

Area for additional breeding work

Accessions **7-23-35** and **7-32-5.4** may be worthwhile for breeding, but their pit shapes preclude them from being released as commercial varieties. It was noted that the fresh taste of **7-32-5.4** is one of the best of all the accessions. The best of the light cherries, **7-32-5.4,** was be crossed with other promising accessions to develop a good pie cherry.

genotype	weight (gm) / cherry			soluble solids	thawed weight	percent crack	percent rot	qualitative traits		
	flesh	pit	total	(Brix)	retention (%)	resistant	resistant	colour	pit shape	fresh flavour
Montmorency[Z]			4.8	11.0				light	round	
7-21-16.3	**5.4**	**0.3**	**5.8**	**17.1**	**72**	**0**	**58**	**medium-dark**	**round**	**good**
7-23-35	**4.9**	**0.3**	**5.2**	**15.2**	**60**	**16**	**70**	**medium**	**oval**	**bland**
7-32-5.4	**4.4**	**0.3**	**4.6**	**13.2**	**62**	**40**	**96**	**light**	**elongated**	**good**
Evans	4.3	0.3	4.6	11.8	41	Y	Y	light	elongated	good
7-19-27.3	4.2	0.3	4.5	14.4	63	44	100	light	round	sour
7-25-24.7	4.1	0.3	4.4	14.6	60	44	50	dark	slightly elongated	good
7-21-31.0	**4.1**	**0.3**	**4.4**	**16.9**	**62**	**20**	**80**	**medium**	**round**	**good**
7-32-11.6	4.1	0.2	4.3	15.0	67	26	56	dark	elongated	good
7-19-21.3	4.1	0.3	4.4	14.3	60	54	48			
7-17-29.75	4.0	0.3	4.3	14.9	61	0	74	light-medium	round	good
7-27-24.4	4.0	0.3	4.3	15.9	62	10	76			
7-4-28.2	3.9	0.2	4.2	15.8	69	18	80	medium	round	bad
7-29-28.2	3.9	0.3	4.2	15.9	65	92	74	light	elongated	bland
7-31-13	3.9	0.3	4.2	15.1	64	44	100	medium	round	sour
7-23-13.2	3.9	0.4	4.3	13.7	63	8	58		round	
7-7-5.8	3.9	0.3	4.2	15.4	62	22	70	dark	slightly elongated	good
Carmine Jewel	**3.9**	**0.2**	**4.0**	**12.4**	**58**	**66**	**100**	**dark**	**round**	**good**
7-19-35	3.8	0.3	4.1	15.2	64	58	90	medium-dark	slightly elongated	bland
7-32-1.7	3.8	0.2	4.0	13.3	59	76	66	medium-dark	slightly elongated	sour
5-32-8.3	3.7	0.2	3.9	14.3	57	0	98	dark	oval	good
7-5-29.45	3.7	0.2	3.9	14.5	62	16	84	medium-dark	round	good
7-29-3	3.6	0.2	3.9	12.5	64	44	78			
7-4-36	3.6	0.3	3.9	17.3	68	44	92	medium	round	good

[Z] Montmorency is the industry standard for North America, it cannot be grown here. Data is from Iezzoni and Karle, 1998.

[Y] Not enough Evans fruit was available for the crack or rot tests.

Table 2.1. Dwarf cherry evaluations, continued.

genotype	weight (gm) / cherry			soluble solids (Brix)	thawed weight retention (%)	percent crack resistant	percent rot resistant	qualitative traits		
	flesh	pit	total					colour	pit shape	fresh flavour
7-29-32.9	3.6	0.1	3.7	13.0	62	58	84	dark	oval	bland
7-7-32.85	3.6	0.3	3.9	17.7	64	0	84	light	oval	bland
7-17-31.2	3.6	0.3	3.9	14.0	69	34	44	light	slightly elongated	bland
7-4-24.4	3.6	0.2	3.8	16.1	68	8	78	medium	round	bad
7-6-23.45	3.5	0.3	3.8	15.5	61	28	92	medium-dark	round	bad
7-19-17.2	3.4	0.2	3.7	14.3	66	26	78	medium	round	bland
7-5-59	3.4	0.2	3.6	15.8	60	14	80	light	oval	bland
7-19-9.5	3.3	0.2	3.5	13.0	62	72	96	light	round	bland
7-21-13.25	3.3	0.2	3.5	13.3	71	70	62	medium	slightly elongated	sour
7-8-5.4	3.2	0.1	3.4	15.1	66	16	88	light	round	good
7-19-21.95	3.2	0.2	3.4	13.7	69	6	100	light	round	sour
7-27-15.3	3.2	0.2	3.4	14.8	67	62	80	medium-dark	slightly elongated	good
7-25-15.1	3.2	0.3	3.4	12.3	60	86	38	light	round	bland
7-17-34.05	3.1	0.3	3.4	13.0	68	.	98	medium	slightly elongated	sour
7-27-18.1	3.1	0.3	3.3	14.4	66	80	16	light-medium	slightly elongated	good
7-25-28.3	3.0	0.2	3.2	15.6	65	16	80	dark	oval	sour
7.33-27.6	3.0	0.2	3.2	13.4	61	26	50	light-medium	round	bad
7-27-27.4	3.0	0.2	3.2	15.3	59	54	98	medium-dark		
7-6-6.5	3.0	0.3	3.3	15.1	65	50	100	light-medium	slightly elongated	sour
7-31-34.45	3.0	0.2	3.2	11.9	60	46	92	medium	elongated	bland
7-19-36.7	3.0	0.2	3.2	13.3	61	50	56	medium-dark	oval	bad
7-27-21.6	2.9	0.2	3.2	13.4	61	24	92	light-medium	round	bland
7-4-44.2	2.9	0.2	3.1	14.8	56	8	94	light-medium	elongated	bland
7-4-35.7	2.9	0.2	3.1	13.5	59	86	82	medium-dark	oval	bland
7-4-27.2	2.9	0.2	3.1	14.4	65	8	68	medium	round	bland
7-23-22.55	2.9	0.2	3.1	12.5	56	46	96	medium	slightly elongated	bad
7-5-54.6	2.9	0.2	3.1	15.6	61	62	84	light-medium	round	sour
7-25-29.4	2.8	0.2	3.0	15.9	68	50	70	medium-dark	slightly elongated	sour
7-17-33.1	2.8	0.2	3.0	14.4	65	62	40	light	round	bland

Table 2.1. Dwarf cherry evaluations, continued.

genotype	Weight (gm) / cherry			soluble solids (Brix)	thawed weight retention (%)	percent crack resistant	percent rot resistant	qualitative traits		
	flesh	pit	total					colour	pit shape	fresh flavour
7-17-16.4	2.8	0.3	3.1	16.6	68	20	92	light-medium	round	bland
7-17-13.75	2.8	0.2	3.0	13.0	74	52	86	dark	slightly elongated	bland
7-27-32.6	2.7	0.2	3.0	.	0	76	78	dark	round	sour
7-5-41.4	2.7	0.2	2.9	15.8	60	22	98	dark	round	good
7-4-40.65	2.7	0.2	2.9	17.1	64	36	92	dark	round	bad
7-3-2.15	2.6	0.2	2.9	14.6	66	48	90	light-medium	slightly elongated	bad
7-19-8.1	2.6	0.2	2.9	14.4	69	84	78	light	round	bland
7-27-18.9	2.6	0.2	2.8	14.8	68	70	82	light	slightly elongated	sour
7-17-12.4	2.5	0.2	2.7	14.2	71	0	80	light-medium	slightly elongated	sour
7-6-16.1	2.3	0.2	2.5	17.5	66	96	92	dark	round	sour
7-6-50.25	2.3	0.2	2.5	13.0	65	22	92	medium	oval	bland
7-29-26.7	2.2	0.2	2.3	14.0	61	.	100	dark	round	bland
7-17-18.5	2.1	0.2	2.3	14.7	67	76	68	dark	round	good
mean	3.3	0.2	3.6	14.6	63	40	79			

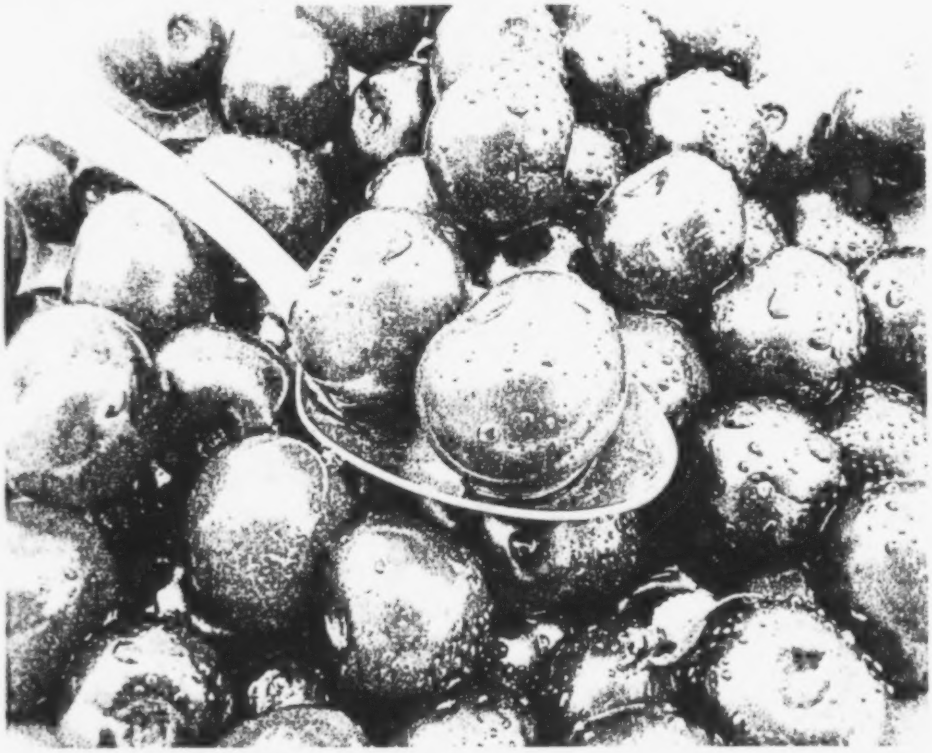
Cherry crosses, October 2001

Perhaps 10,000 crosses were done between advanced selections with only about 10% success rate. Such low rates are common in sour cherry breeding according to breeders I met at the Cherry Symposium.

Virus certification of SK Carmine Jewel and 7-17-16.3, October 2001

Plants of SK Carmine Jewel and 7-21-16.3 have been sent for virus certification and cleanup if needed. 7-21-16.3 has continued to be our best tasting, high quality accession with the second largest fruit size of all cherries in our program. Growers who have tasted are extremely positive about it becoming released.

Figure 2.1. Close-up of SK7-21-16.3.



Cherry germplasm

Budwood of 10 Sour Cherry cultivars were obtained from Bill Lay, University of Guelph (see table 2.2). These were successfully grafted onto seedling rootstock growing in our greenhouse in early spring. When this material matures and bloom they will be used as parents in the next generation of Dwarf Sour Cherry

Breeding. Bill Lay recommended these varieties as having either superior cold hardiness or superior fruit quality.

Extensive evaluation of 2000 seedlings at the Hamilton Orchard resulted in 15 selections being made from the descendants of Les Kerr's breeding program. Seeds were gathered from these and ~200 were planted. These hybrids will be crossed the varieties listed in table ??? to in future breeding. This will greatly expand the germplasm base of our breeding program for this crop.

Table 2.2. Ten sour cherry cultivars obtained for the breeding program.

Cacanski Rubin
Cigancia
Fruchbare von Michurin (PI 205800)
Goresemka
Heimanns Konserva
Heimanns Rubin
Planteskole og Frohandel (PI 199027)
Schattenmorelle
Sour Chari
Stevensbaer

Mechanical harvesting studies on dwarf sour cherries

Pull force measurements and ethephon treatments, 1999

A study determined that dwarf sour cherries have potential to be mechanically harvested. Tensiometer readings taken using a Force Gauge (Type MF-2, Shimpo American Corp., Lincolnwood, Ill.) and tested 50 fruit per selection. This experiment showed that sour cherries require 100 or less force/fruit weight. According to engineer, Miles Bantle, these cherries are much easier to harvest mechanically than saskatoons (Table 2.3). Trees were easily harvested by hand late in the season by shaking the branches 3 to 5 times and using a tarp to collect fruit. It is quite likely that an over the row raspberry harvester could be adapted to rapidly remove cherry fruit, or that lower cost equipment could be developed.

Table 2.3. Tensiometer readings of 7 sour cherries including ethephon treatments to Carmine Jewel.

Ethephon treatment	genotype	force/fruit weight	Std. error
250 ppm	Carmine Jewel	29	13
0 ppm	7-6-6.5	53	14
	Carmine Jewel	60	16
	7-4-36	60	30
	Evans	64	15
	7-5-29.45	78	18
	7-7-5.8	96	23
	7-6-23.45	100	21

Catch frame invented for shake harvesting

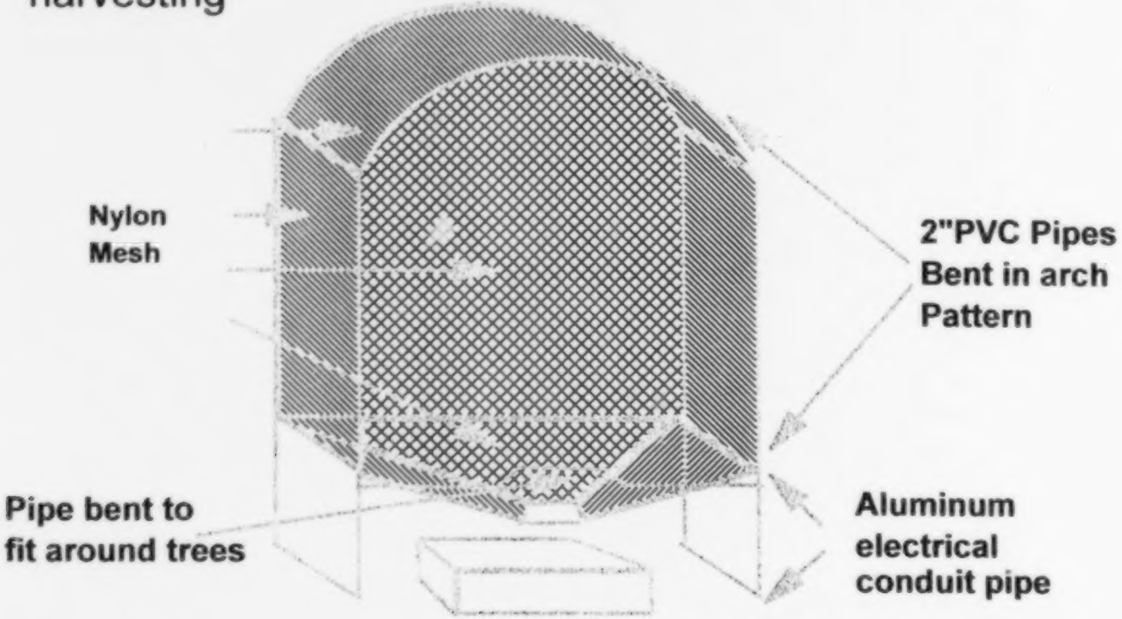
Picking cherries by hand had taken 30 to 60 minutes depending on yield. In 1999 we tried a BEI hand held harvester. This device is a three fingered vibrator that is combed over branches to remove fruit. It was used to harvest saskatoon berries by the Native Fruit Development Program. This method was found to be more difficult than simply shaking the branches by hand. A flat catch frame that is used in tandem with the hand held BEI was unsuitable for shake harvesting since 30% of the cherries did not land on the tarp. A catch frame with tall sides was designed and built by Bob Bors, Forrest Scharf and Rick Sawatzky to better catch the cherries (see Figure 2.2).

It works by inserting the frame into the tree and shaking the branches by hand. Slapping two branches against each other is quite effective. With the upright catch frame time is reduce to 3 mins per tree (or 1.5 mins per half of a tree)! This method was found much easier to do than using the BEI hand held harvester that works by vibration. Loss of fruit was reduced to less than 5% of yield.

The catch frame should cost less than $500 to build including labour. This device will be an excellent low cost way for harvesting cherries for the beginning orchardist, who may not yet be able to afford over-the-row harvesting equipment.

A blue berry grower from BC and an instructor of fruit classes in Quebec have described this device as ingenious. They had not seen anything like this device before and suggested that it could have applications for other crops. We believe it will be easily adaptable to harvesting blue honeysuckles. A suggested modification would be to make the legs adjustable as the lowest fruiting branches of blue honeysuckles are close to the ground while cherries are higher.

Figure 2.2. Catch Frame for Dwarf Sour Cherry harvesting


Nylon Mesh
2"PVC Pipes Bent in arch Pattern
Pipe bent to fit around trees
Aluminum electrical conduit pipe

Approximate dimensions: 2 m (height) x 1.5 m (width) x 0.75 m (depth)

International Cherry Symposium, October 2001

Bob Bors presented a paper on the Dwarf Cherry Breeding program to the Fourth International Cherry symposium in Hood River, Oregon, June 2001. The paper written for the symposium is follows this section and will be published Acta Horticulturae. Highlights of the conference include:

1. Only the U. of Sask. and U. of Michigan have sour cherry breeding programs in North America. There are five sour cherry breeding programs in Europe, but only three were in attendance. Dozens of programs exist for sweet cherries.

2. U. of Sask. sour cherries have very high sugar content compared to other programs. Size and quality seems to be comparable or better than cherries being developed in other programs.

3. Only the breeding program in Sweden is attempting to breed Dwarf Sour Cherries for over the row harvesting. All other programs have tall trees that require more expensive harvesting equipment.

4. The best areas in the world for growing cherries are dry regions with irrigation.

5. I was able to sample 'Montmorency' sour cherries (#1 cultivar in the USA). I found them to be of inferior flavour, size and appearance to our advanced selections.

6. U of S cherries have an unusually long harvest window. This could be due to the wild species *P. fruticosa* used in our breeding program or perhaps disease pressure from fruit-attacking microbes is less.

7. Michigan has difficulties with leaf spot and frost damage from early blooming. Neither of these has been a problem with our germplasm. The *P. fruticosa* that was used in our program to increase cold hardiness may also be a source for disease resistance and late blooming!

From the conference it was evident that the U of S was a leader in sour cherry development. Contacts were made to enable co-operative exchanges of germplasm. I was particularly pleased that the breeder in Hungary agreed to send pollen from his sweet cherry / sour cherry hybrids for use in our breeding program.

Note: the following paper was presented to the International Cherry Symposium in Oregon and Washington State, in 2001. The research mentioned in this paper was funded by this project.

Dwarf Sour Cherry breeding at the University of Saskatchewan

R. H. BORS
DEPARTMENT OF PLANT SCIENCES
UNIVERSITY OF SASKATCHEWAN
SASKATOON, SK. S7N 5A8
CANADA

Keywords: *Prunus, cerasus, fruticosa,* cold hardy, mechanical harvest.

Abstract

Sour Cherry breeding on the Canadian Prairie began in the 1940's when Dr. Les Kerr began hybridizing *Prunus fruticosa x P. cerasus*. In 1966, the University of Saskatchewan initiated sour cherry research with *P. fruticosa x P. cerasus* seeds from the Siberian Botanical Gardens. After inheriting Dr. Kerr's advanced selections in 1983, controlled crosses were made between hardy selections and sour cherry cultivars from Europe. In recent years Dwarf Sour Cherries with commercial potential have been selected. Many of the resulting hybrids possessed cold hardiness, dwarf stature and good fruit quality. Bred at a zone 2B site, selections have been successfully tested in Zones 2 and 3. Soluble solids of advanced selections started from 14 to 17degrees Brix in late July and increased steadily from 16 to 22 degrees Brix in late August. Many seedlings have 4.0g fruits but only two selections average greater than 5.5g fruits. Height of seven and eight year seedlings ranged from 1.0 to 3.1m and averaged 2.4m. Pull force tests indicated fruit could be mechanically harvested as early as late July and ease of detachment remained constant to the end of August. Number of suckers ranged from 0 to 24 with an average of seven per tree. Most fruits in the population are a dark red or black when fully ripe but a few are bright red. Diseases are extremely rare in all test sites in Saskatchewan. It is not known if this is due to resistance or avoidance. A very early ripening selection, SK Carmine Jewel, was released in 1999. A large fruited, mid season selection is planned for release in 2002 or 2003.

1.0. Introduction

Although Saskatchewan is primarily a grain-producing region, the University of Saskatchewan has long been committed to developing alternative crops for farmers. Fruit breeding has been ongoing at the University since the 1920's and has received increased funding in the last decade. While 48% of Canada's tillable land is located in Saskatchewan, only one million people reside in the province. Consequently, labour is in short supply and mechanically harvested crops have the greatest commercial potential. Emphasis has been to select dwarf sour cherries that can be picked with over-the-row harvesters. Such harvesters are already in use by growers to harvest saskatoons and raspberries but have potential for dwarf sour cherries (Trajkovski, 1996).

With winter lows of –40°C (Zone 2), cold hardiness has been a primary focus of prairie breeding programs for several decades. With several generations of selection, winter survival has been gradually improved and development of advanced selections with good fruit quality has recently occurred. Most producers of Dwarf Sour cherries have pick-your-own operations and are growing seedlings and advanced selections from the University of Saskatchewan breeding program. With the release of the University of Saskatchewan's first dwarf sour cherry cultivar 'SK Carmine Jewel' in 1999, many growers are growing sour cherries for the first time. A challenge to the breeding program has been to educate growers in fruit production practices and to assist in the development of post harvest infrastructure. Growers are advised that sour cherry production in Saskatchewan is considered experimental.

1.1. Sour Cherry breeding

1.1.1 History

Sour cherry breeding began in 1944 when Les Kerr began *hybridizing Prunus fruticosa* and *P. cerasus*. Dr. Kerr left no records of the parents used in his crosses, but it is known that he mainly used bulk pollen in his breeding program. By the mid-1950's nurseries on the Canadian prairie began selling "Mongolian cherries" from Les Kerr's ongoing breeding program. As a director of the Dominion's Forestry Farm in Saskatoon, Dr. Kerr provided windbreak trees for Saskatchewan and had many farmers across the province testing his seedling cherries under a wide range of harsh conditions. As he selected for precocity and propagated these cherries only by seed, it is probable that he crossed and selected five or six generations during his career.

In 1966 Dr. Stewart Nelson imported 500 seeds of *P. fruticosa* from the Siberian Botanical Gardens and two decades of mass selection of open pollinated seedlings began. It was noted that seedlings from the Siberian Botanical Gardens were highly variable in cold hardiness, stature, and fruit size, indicating that some of the seeds may have been *P. fruticosa* x *P. cerasus* hybrids.

Dr. Kerr bequeathed his advanced selections to the University of Saskatchewan in 1982. At that time, Dr. Cecil Stushnoff and Rick Sawatzky began obtaining *P. cerasus* cultivars for breeding purposes. The Kerr and Siberian sources of germplasm were merged into one population and current generation consists of 15,000 trees at 12 co-operator sites. As hardiness became improved, selection began for enhance fruit quality.

Controlled crosses between advanced selections of *(P. fruticosa x P. cerasus)* hybrids and *P. cerasus* cultivars began in 1987. In 1999, the University of Saskatchewan released its first dwarf sour cherry cultivar, SK Carmine Jewel ('Kerr's Easypick' x 'Northstar'). From 1996 to 2000 advanced selections were backcrossed a second time to *P. cerasus* cultivars resulting in 300 to 500 trees per year.

A study was begun in 1999 to evaluate the three sour cherry populations for commercial potential and develop a strategy for future breeding. Those populations are: *(P. fruticosa x P. cerasus)*, *(P. fruticosa x P. cerasus)* x *P. cerasus* {BC1} and [*(P. fruticosa x P. cerasus)* x *P. cerasus*] x *P. cerasus* {BC2}.

1.1.2. Breeding goals

Cold hardiness has become established in most breeding lines allowing selection for other attributes. Selection pressure in recent years has emphasized fruit quality and potential for processing and mechanical harvesting. Important characteristics include: productivity, good flavour, high soluble solids, round pits, red to dark red flesh and juice, few suckers per tree, dwarf stature, and easily detached fruit. Currently, there is demand in Saskatchewan from pick your own farms and juice processors for sour cherries.

2.0. Materials and methods

2.1. Germplasm

The source for cold hardiness was *P. fruticosa* from the Kerr breeding program and from the Siberian Botanical Gardens. Germplasm from these two sources also contained *P. cerasus* but it is uncertain what percent contribution was made by each species. Although 15 named cultivars of *P. cerasus* have been used since 1987, the most widely used cultivars for hybridization have been Cacanski Rubin, Northstar, Kelleris 14 and Erdi Jubileum. All germplasm in the field was on its own roots as seedlings, tissue culture plants, or clones from cutting propagation. The *P. cerasus* cultivars are maintained as grafted potted trees and are placed in a cooler during the winter. Seedlings and selections from the program were located at the University of Saskatchewan in Saskatoon and at various grower sites throughout Saskatchewan. The sour cherry cultivar "Evans cherry" (*P. cerasus*) was observed and compared to advanced selections. The lineage of four advanced selections is in Table 1.

2.2. ATTRIBUTES STUDIED.

Attributes studied include: disease incidence, winter survival, tree height, fruit retention force; soluble solids; flavour, fruit weight, pit shape, suckering, productivity, fruit colour, and juice colour. Of special interest was research into potential for using over the row harvesters ordinarily used for Saskatoon berries, blueberries, and raspberries. An over the row harvester could not be used in the seedling orchards as many accessions sucker profusely, but fruit retention force measurements were done (Bantle, 1996) on promising selections.

3.0. Results and discussion

3.1. Pests

Bacterial canker and powdery mildew have occasionally appeared at very low frequencies at the Saskatoon breeding site and are rare elsewhere in the province. Leaf spot has not been observed or reported. It is not known if the low disease incidence is due to resistance, avoidance, or perhaps the dry summers and cold winters of Saskatchewan are not conducive to diseases or their vectors. At the Saskatoon site, dwarf sour cherries are sprayed two or three times for cherry fruit fly and this is the only spraying done. Most growers do not spray their trees. The most important pest of sour cherries in Saskatchewan is deer. They seem to prefer cherry trees to other fruits commonly grown.

3.2. (*P. fruticosa* x *P. cerasus*) hybrids

The (*P. fruticosa x P. cerasus*) hybrids had the least amount of winter damage of the three populations. The four to six year old bushes averaged 1m tall and were usually heavily suckered. In older plantings dense hedges were formed. Fruit size tended to be less than 3g and flavour was mostly very sour with astringency very common in the population. This population was not studied in detail as it was judged to have low commercial potential. About 2% of the population had few suckers and about 5% were late flowering. Several selections are being further evaluated for use in the breeding program.

3.3. BC2

Winter damage occurred in 50% of BC2 trees after the winter of 2000/2001. Many of the one and two year old seedlings showed damage which may have been precipitated by an unusually dry fall with little snow cover when temperatures dropped to –30C in November of 2000. Injury has been very rare in (*P. fruticosa x P. cerasus*) and BC1 trees during the first two years. Cold hardiness did not seem to be related to plant vigour. The surviving BC2 hybrids are too young to fully evaluate as the oldest of these is just beginning their fourth leaf and most have not borne fruit.

3.4. BC1

Of the three populations, BC1 hybrids have the best commercial potential. Survival rate was difficult to establish since undesirable trees had been removed but 70% of the seedlings remained after eight or nine years. Height of eight or nine year seedlings ranged from 1.0 to 3.1m and averaged 2.4m. Number of suckers ranged from 0 to 24 with an average of seven per tree. Many trees were between 1.75 and 2.25m tall with less than five suckers. This combination of characters was considered desirable for harvesting with an over the row harvester.

3.4.1. Productive BC1 accessions in1999

From a population of approximately 2500 seedlings, 61 were judged to be highly productive, cold hardy and had desirable height. Fruit weight of these 61 accessions ranged from 2.3 to 5.8g with 18 selections averaging 4.0g or more. Soluble solids ranged from 11.8 to 17.7 Brix on the second week of August in 1999. Yields from a few trees having a meter spacing, on either side, ranged from six to nine kg / tree. Yields have not been taken on most trees in the seedling orchard.

3.4.2. Advanced BC1 selections in 2000

BC1 selections 'SK Carmine Jewel', 7-21-16.3, 7-21-31.1, 7-32-5.4 could be harvested 16 to 20 days earlier than the *P. cerasus* cultivar 'Evans Cherry' according to pull force measurements (Figure 2). Fruit retention force of less than 100g of force /g of fruit is considered acceptable for over the row harvesting (Bantle, 1998). Cherries could easily be removed by shaking the University of Saskatchewan selections by hand and using a catch frame. 'Evans' could not be harvested by this method, as its branches were much larger and harder to shake.

All cherries had a similar trend for the increase of soluble solids (Figure 1). As the flesh to pit ratio decreased from mid August for U. of S. selections, dehydration likely played a role in the increasing trend in soluble solids. The Evans cultivar continued to increase its flesh to pit ratio during the time of the study. The cherries in this study have not received irrigation since the first three years of establishment. It is possible that irrigated trees would have a slower rate of dehydration.

3.4.3 Selections with commercial potential

SK Carmine Jewel' and 7-21-16.3 have the greatest commercial potential of the advanced selections. Both have good flavour, black skin, dark red flesh and dark red juice, can be easily shaken from trees, and had fruit retention force in an acceptable range from late July to late August (Figure 1). Height, suckering and pit shape data indicate that only 'SK Carmine Jewel' and 7-21-16.3 have potential for over the row harvesting as well as mechanized pit removal (Table 2). If methods for sucker control were developed 7-21-31.0 could be acceptable. Since elongated pits are more susceptible to chipping (Iezzoni, 1996) 'Evans Cherry' and 7-32-5.4 would not be suitable for mechanical pitting.

SK Carmine Jewel becomes dark red in mid July, compared to early August for most other cherries in the program but its flesh to pit ratio indicates August 8 to 16 may be a better time to harvest. Its high flesh to pit ratio may make it especially appealing for beverage manufacturing.

The large fruit of 7-21-16.3 may be very attractive for pick your own customers and perhaps canning. Most growers who have tasted it find it acceptable for fresh eating. A notable drawback is that the tree is the least vigourous of the advanced selections and probably should be planted at a higher density per acre. 7-21-16.3 is currently being tested for viruses and will be released for test purposes in the near future.

4.1.0 Acknowledgements

Saskatchewan Agriculture and Food provide ongoing funding. Rick Sawatzky has been a breeder in the dwarf sour cherry program since it started at the University.

Forrest Scharf, Heather Hack and Heather Drysdale gathered much of the data.

5.1.0 References

Bantle, M.R.L., R.G. St. Pierre and D. Wulfsohn. 1996. Mechanical harvesting trials on Western Canadian native fruits. Presented at the Agricultural Institute of Canada Annual Conference, July 7-10, 1996, Lethbridge, Alberta, Can. Soc. Agric. Eng. Paper No. 96-403

Bantle, M.R.L. 1998. An Economical Mechanical Harvester for Saskatchewan Fruit Crops: Final Report Project 93000056. Saskatchewan Agriculture and Food, Regina, Saskatchewan. p.33.

Iezzoni, A.F. 1996. Sour cherry cultivars: objectives and methods of fruit breeding and characteristics of principal commercial cultivars. In Cherries: crop physiology, production and uses. Edited by A.D. Webster and N.E. Looney. CAB International, University Press, Cambridge, UK.

Trajkovski, V. 1996. A review of the cherry breeding program in Sweden. Proceedings of the International Cherry Symposium. Acta Hort. 410:387-388.

Table 2.4. Lineage of advanced selections.

ACCESSION	Female parent	Male Parent
7-21-16.3	Kerr's Easypick[Z]	Cacanski Rubin
7-21-31.0	Kerr's Easypick	Cacanski Rubin
7-32-5.4	Egbert Centre[Y]	Kelleris 14
SK Carmine Jewel	Kerr's Easypick	Northstar
Evans	Unknown lineage, suspected to be a Meteor seedling	

[Z] *P. cerasus* x *P. fruticosa* hybrid from Les Kerr's breeding program

[Y] *P. cerasus* x *P. fruticosa* hybrid from Siberian Botanical Gardens

Table 2.5. Comparison of advanced selections in 1999 and 2000. Evans is a *Prunus cerasus* cultivar while other selections are (*P. cerasus* x *P. fruticosa*) x *P. cerasus* hybrids from the U. of Saskatchewan breeding program.

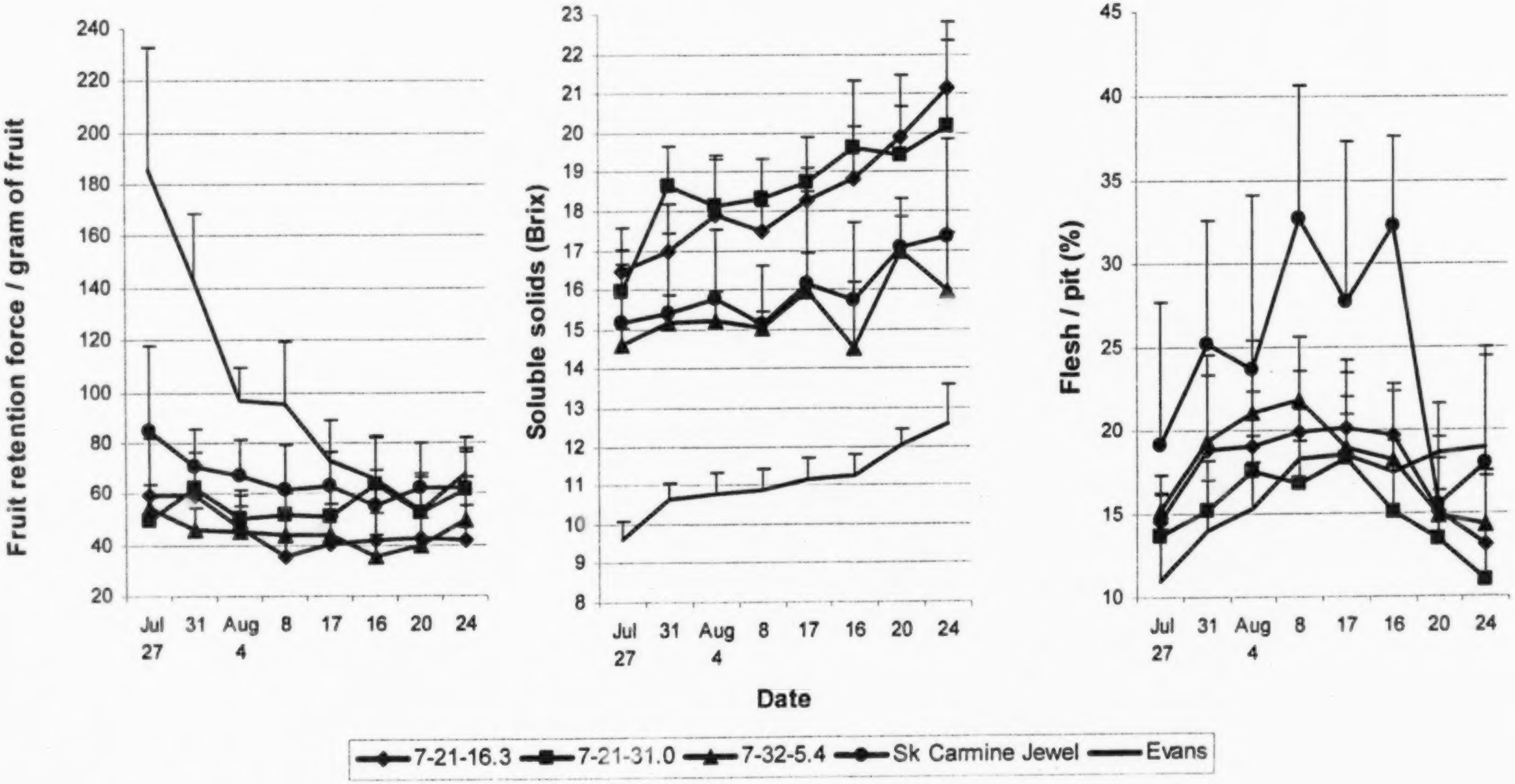
Accession	Age	height	suckers	mean fruit wt (g)		qualitative traits			
		(m)	/ tree	1999[Z]	2000[Y]	skin colour	flesh colour	pit shape	flavour
7-21-16.3	9	2.2	0	5.5	5.2a	black	dark red	round	good
7-21-31.0	9	2.2	10	4.5	3.7c	black	dark red	round	good
7-32-5.4	9	2.8	5	4.7	5.2ab	red	pink	elongated	good
SK Carmine Jewel	7	2.1	4	4.1	3.3d	black	dark red	round	good
Evans	7[x]	3.2	15	4.6	4.3b	red	yellow	elongated	good

[Z] based on bulk samples of 50 to 100 fruit

[Y] letters indicate LS means separation at 5%

[X] winter killed to ground after third season

Figure 2.3. Fruit retention force, soluble solids, and flesh to pit ratios for advanced selections in 2000. Evans is a *Prunus cerasus* cultivar while other selections are (*P. cerasus x P. fruticosa) x P. cerasus* hybrids from the U. of Saskatchewan breeding program.



Cherry processing

2000

Superstore, Superfresh, Safeway, and IGA grocery stores in Saskatoon were visited and cherry products being sold were noted and some products were purchased for testing. Photos were taken of these products and were used for grower talks.

It was noted that many cherry products contained red dyes or very few cherries. Cherry products in Saskatoon have been imported from Switzerland, Poland and Hungary, indicating that perhaps there is a Canada wide shortage of sour cherries.

Processing Quality of frozen fruit, 2001

In previous years dwarf sour cherries were evaluated on a fresh taste basis. This year's studies focus on processing uses including juice and cooked with frozen fruit. The components were separated into flesh, juice and seeds with the fruit and juice being frozen for later study and the seeds kept in moist sand for a germination study. Parameters being tested are soluble solids, total acidity, weight retention after cooking (cooking releases juice) and flavour after processing. The total acidity test have recently begun but completion of the study will not occur until the next report. Three groups of experiments are ongoing:

Affect of delay in processing

Five selections were harvested and cooled at the same time. Then in 24 hour intervals, over a 5 day period, they were processed and frozen. This should give information for fruit processors regarding how quickly they should process their fruit.

In this study were included selections with light and dark coloured flesh. It is known that dark coloured flesh contains more anti-oxidants and should have better quality than light coloured fruit.

Processing experiments,2002

An estimated 500 samples were taken which occupy 2/3rds of a chest freezer. The evaluation of the frozen fruit was planned to continue through the winter months but a lapse in funding in Mid November prevented further studies with this material.

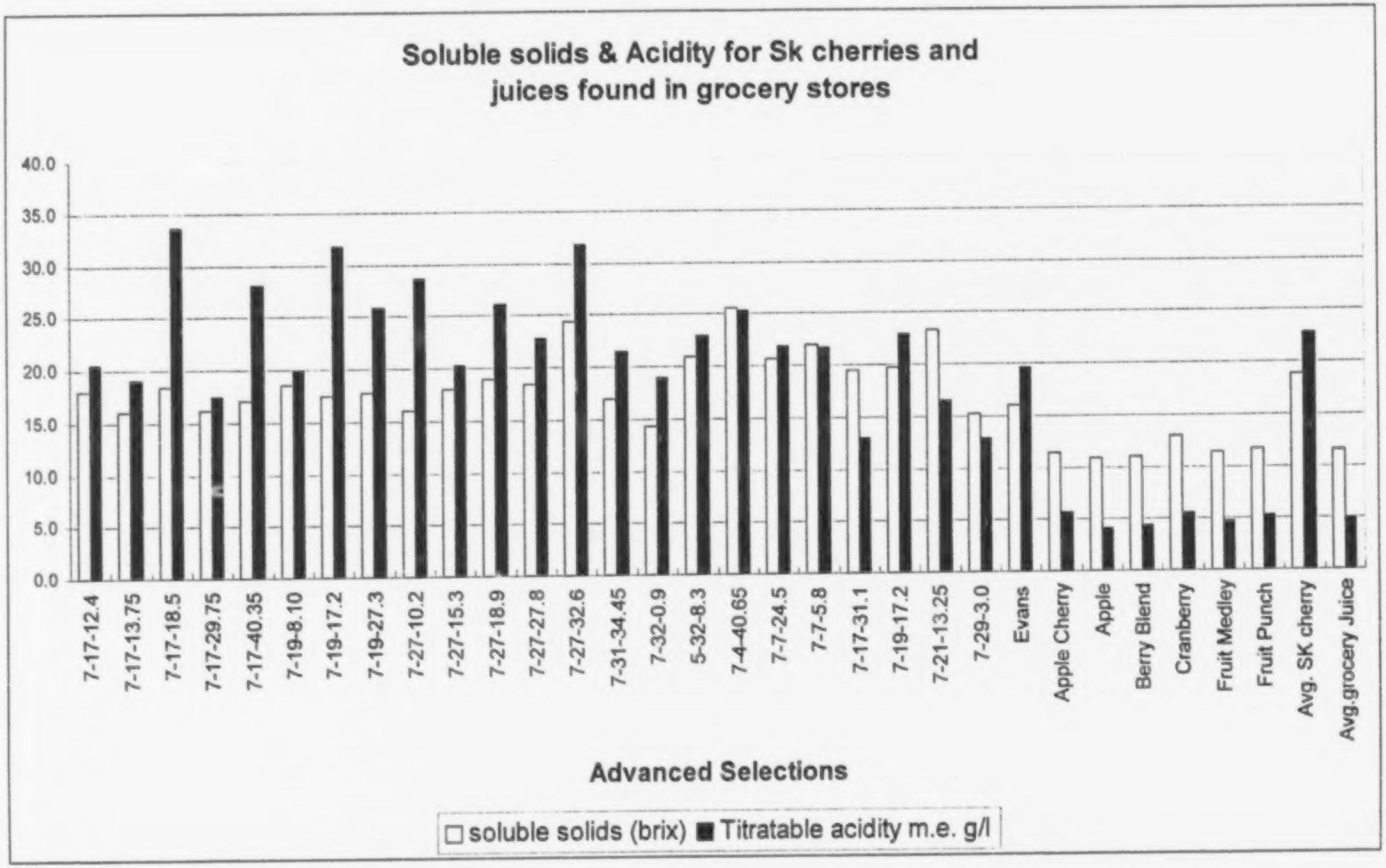
Processing Quality: SK Sour Cherry Juice is superior and highly concentrated compared to fruit juices in grocery stores, April 2002

An undergraduate student, Megan Payne, did her undergraduate thesis on analysing our cherries for juice quality. Megan did much of this research during the summer as an employed summer student in our program but later in the fall she completed chemical analysis of the various lines. Her data as well as other data taken in recent years is being written into a scientific paper. the following is an excerpt from the conclusion section of her thesis:

> "Dwarf sour cherry selections from the University of Saskatchewan have good commercial potential for their juice quality. Most of the sour cherry selections were superior as compared to the commercial variety 'Evans'. This light fleshed, semi-sweet tasting cherry, had the fourth lowest level of acidity and second lowest level of soluble solids. The colour for 'Evans' juice was third lightest. Overall, the selections, 5-32-8.3, 7-4-40.65, 7-7-5.8, 7-7-24.5, 7-19-17.2, and 7-29-3.0 proved superior to 'Evans', with higher acidity, soluble solids, and colour. The highest acidity levels occurred in 5-32-8.3, 7-4-40.65, and 7-19-17.2.
>
> Comparing the nine sour cherry selections to the six commercial juice products, all were superior. The selections contained higher amounts of acidity, soluble solids, and colour than required for commercial juice products. The highest soluble solids were found in 7-4-40.65, 7-21-13.25, and 7-7-5.8.
>
> Of the nine sour cherry selections tested, the selections with the darkest flesh and juice colour, high soluble solids, and increasing acidity over time seem to be the most promising. The dark juice colour allows for dilution to occur while maintaining high colour levels, and as the colour darkens with time, harvest could be prolonged. The high soluble solids also allow for dilution to occur without having to add additional sugars, or perhaps little added sugars. The increasing acidity over time allows for neutralization to occur. As acidity and soluble solids are both increasing over time, there would be less variation between the two so that harvest could be prolonged while maintaining a similar ratio of soluble solids to acidity. Of the sour cherry selections that were evaluated in this study, 5-32-8.3, 7-4-40.65, 7-7-24.5, and 7-7-5.8 show the most promise.
>
> There are also many other factors that were not examined here, such as other cultivars, temperature, water supply, fertility, age of the trees, heredity linkage to parental plants, processing losses, and production practices, that could all greatly influence the juice quality of the sour cherries. Therefore, as this study only analyzes the juice quality of the cultivars produced at the University of Saskatchewan, this is only the beginning stage of the research. After determining the selected sour cherry cultivars of commercial importance for the juice industry, the aspects of viable production, harvest, processing, and marketing as areas of future research needs."

Figure 2.4. Combines Megan's data with other analysis done this winter.

Figure 2.4.


Soluble solids & Acidity for Sk cherries and juices found in grocery stores
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
7-17-12.4
7-17-13.75
7-17-18.5
7-17-29.75
7-17-40.35
7-19-8.10
7-19-17.2
7-19-27.3
7-27-10.2
7-27-15.3
7-27-18.9
7-27-27.8
7-27-32.6
7-31-34.45
7-32-0.9
5-32-8.3
7-4-40.65
7-7-24.5
7-7-5.8
7-17-31.1
7-19-17.2
7-21-13.25
7-29-3.0
Evans
Apple Cherry
Apple
Berry Blend
Cranberry
Fruit Medley
Fruit Punch
Avg. SK cherry
Avg.grocery Juice
Advanced Selections
□ soluble solids (brix) ■ Titratable acidity m.e. g/l

Affect of delay in processing, April 2002

Five selections were harvested and cooled at the same time. Then in 24 hour intervals, over a 5 day period, they were processed and frozen. Data from this study showed minimal differences in soluble solids or changes in acidity. It seems likely that the antioxidants present in sour cherry fruit prevent changes in Soluble solids or acidity during such a short period of time. Delay in processing could result in rot developing, although this did not occur in our experiment.

Co-operative fruit breeding project, 2002

Note: The following project was initiated to allow widespread propagation and testing of our dwarf sour cherries. The project concept is planned for use in introducing our apple lines and will be used in the future for other fruit crops.

Summary

This project creates a framework for the testing, releasing and eventually naming new fruit varieties. The following (except for the History Section) is an excerpt from the "Application to Propagate"

History

Spanning 2002 was the development of this project conceived by Dr. Bob Bors. Meetings were made with the Plants Science Department's Variety Committee. Approval was sought from the Dean of Agriculture Office, Head of the department of Plant Sciences and Office of Research. Discussions and advice occurred Prairie based fruit nurseries, the Saskatchewan Fruit grower's Association, and individual fruit growers. Wording of applications and contracts were similarly reviewed and amended. From the time of conception, 10 months were required to develop this strategy for releasing new fruit varieties.

Purpose

The purpose of this project is to allow testing of new fruit selections developed at the University of Saskatchewan. These selections have shown superior fruit quality, productivity and cold hardiness in Saskatoon, but have not been thoroughly tested in other regions. This project is based on the premise that it is best to test several genotypes of a new crop simultaneously.

Co-operators

Many growers and propagators have expressed a desire to assist in the research and development phases of our breeding program. This project in effect establishes a grower-assisted breeding project. It is hoped that this cooperative effort between researchers, plant propagators and growers will result in the identification of 1. superior cultivars, 2. establish potential production regions for these crops, 3. assist in development of new production systems through grower experimentation, and 4. efficient propagation protocols will have become developed for the mass production of these crops. It is recognized that the item 'superior cultivar' includes such traits as ease of propagation, cold hardiness, taste, fruit quality, and processing value. As production of these selections occurs, other stakeholders could include processors, food distribution networks and consumers. Input from all these areas will be valuable in the development of this project.

Strategy

The Domestic Fruit Program will provide advanced selections as potted trees, *in vitro* cultures or budwood to cooperating propagators. Descriptions and photos of the various selections, and a flier on establishment and care will be provided to propagators, which they can copy, post on websites, or include in their own literature and catalogues.

Propagators will sell these lines only in sets of 5 or more different selections of equal numbers. It is up to the individual propagators to determine if they wish to impose a minimal number of each per order. For example: a propagator may decide that 25 trees is a minimal order, therefore anyone ordering the smallest set will receive 5 trees each of 5 different selections. Propagators will collect a royalty fee for each plant sold which will be paid to the Department of Plant Sciences, University of Saskatchewan on a yearly basis. (It is envisioned that the royalty for dwarf sour cherries will be $0.20/plant; for apples: $0.40/plant.) In the case of apples or any grafted fruit tree, the rootstock chosen for propagation must be approved by the fruit breeder as an improper rootstock could have poor survival.
The royalty fund will be used for virus cleanup, research, breeding, publications of papers and growing guides, extension, purchasing equipment and other activities of the Domestic Fruit Development Program and Plant Sciences Department according to general policies of the department for distribution of royalties.

This project's main focus is on commercial production. For sales of single trees it would be better to propagate extra numbers of already named cultivars, such as SK Carmine Jewel.

It is envisioned that this will be a dynamic and evolving project. Promising new selections will be added for propagation while selections that are judged inferior will be discontinued. As many fruit crops take 4 years until they begin production, it may require a number of years to fully evaluate new selections. Changes in which selections should be offered will be at the discretion of the fruit breeder at the University of Saskatchewan but this will be done in consultation with propagators and growers. Changes in selections will be done in such a way that propagators will be able to dispose of their existing stock before adding new selections. The selections in this project will be advanced selections in the University of Saskatchewan's breeding program. New selections will only be added if superior qualities have already been noted after testing and evaluations at the University's breeding plots.

After the advanced selections have been evaluated for a number of years, breeders, propagators and growers will collaborate in determining which of the advanced selections might be worthy of being released as a named cultivar. Such evaluations may take the form of surveys to growers, visits by the fruit breeders, and feedback from propagators. The U. of S. would then allow the resulting named cultivars to be sold separately. It is very likely that the resulting named cultivars will be registered through COPF, but we are open to suggestions. The propagators that participate in this project would have the advantage of having a large number of propagules in the initial years of release, and would have a significant market advantage over other COPF members .

It is understood that nothing in the corresponding Contract to Propagate will convey exclusive rights to the participants. However, nurseries interested in participating will be informed of the number of participants, and this should limit the number of participants.

Interested nurseries should apply for participation by doing the following:
1. Fill out the form that follows.
2. Submit a letter of intention to participate.
3. Include a brief description of their company.
4. Review the terms and conditions of the contract to propagate

These documents will be reviewed by the Head of the Plant Sciences Department who will approve or reject the application after consultation with the fruit breeder of the Domestic Fruit Program. The applicant will be notified in writing, within 3 weeks of receipt of the application.

Cherry Propagators 2002

The following companies have signed contracts to propagate the Dwarf Sour Cherries as part of the above program. There are 2 additional companies from Saskatchewan that have sent in applications, the paperwork is not yet complete.

These companies have received copies of our tissue culture propagation protocols that had been under this project.

Saskatchewan

Parkland Biotech
Box 11, RR1, Melfort, SK S0E 1A0
(306)752-2629, (306)220-8046
parklandbiotech@gosympatico.ca
www.parklandbiotech.com (soon to be up)

Prairie Plant Systems Inc.
Box 19A, RR5 – 1 Plant Technology Road

Saskatoon SK S7K 3J8
Phone: 306-975-1207 Fax: 306-975-0440
email: elb@prairieplant.com
www.prairieplant.com

Alberta

D 'n A Gardens
Box 544, Elnora, Alberta T0M 0Y0
403-773-2489, fax 773-2400
arden@dnagardens.com
www.dnagardens.com

The Saskatoon Farm
R.R. #1, DeWinton, AB T0L 0X0
1-800-463-2113, 403-938-6245, 403-938-9229
saskfarm@telusplanet.net
www.saskatoonfarm.com

Manitoba

Jeffries Nursery
P.O. Box 402
Portage La Prairie, Manitoba, R1N 3B7
(204)857-5288, (204)857-2877
Jeffnurs@escape.ca
www.jeffriesnurseries.com

DWARF SOUR CHERRY BREEDING, 2002

Field Crosses

Around 4000 pollinations were done in the field. The Hungarian cultivar "Erdi Jubileum" and SK7-21-16.3 were used as pollen parents onto 20 breeding selections. Both these varieties have excellent flavour and high sugar content. About 25% of the pollinations resulted in seeds that will be germinated the coming year.

Open Pollinated Seeds

25,000 seeds were collected from superior lines. 28 growers volunteered their time and planted 20,000 seeds in flats for stratification. In the spring, each grower will receive those flats that they planted and will fall plant the young seedlings that result.
Three out-of- province nurseries (DNA Gardens, AB; The Saskatoon Farm, AB; and Jefferies Nursery; MB) will be planting 5000 seedlings each for our program. This will allow selection in areas where Chinooks and wet environments.

New Trait found in 5 year seedling orchards

A younger orchard of Dwarf Sour cherries began fruiting this year. These are the breeding lines that are 7/8ths Sour Cherry and 1/8th Mongolian Cherry. This plot has had a higher percentage of winterkill and the trees may be too vigourous for easy harvesting. During the evaluation process, two selections (B2 and B5) were found to have a crisp flesh texture similar to sweet cherries. It is quite possible that this trait was inherited from sweet cherries, as the Hungarian breeders have intercrossed sweet and sour cherries, and we have used Hungarian varieties in our program. Unfortunately, neither B2 nor B5 were easily detached and would not be suitable for machine harvesting, and B2's pits are elongated. This crisp-flesh trait however, is very exciting and may be a key trait for the fresh market and may make it easier to ship cherries with less damage. B5 is the better one of the two and will be used in crosses during 2003.

New Seedling Orchard Established

A half acre of seedling cherries were planted at the Saskatoon Field lab. Controlled crosses, open pollinated and bulk lines were represented in equal numbers with about 3000 seedlings in total. Spacing was much closer than for commercial orchards as is common in breeding fields. Wider row spacing will allow over-the-row harvesting of this field.

Five new sour cherry varieties

Data from previous years as well as evaluations occurring in 2002 led to five advanced selections being released as a package for 2003. Comparison of the 5 selections is made to three other varieties in the table below. Plant Breeders rights applications have been sent in for these varieties. Further research will be needed to complete the requirements for PBR.

Table 2.6. Comparison of tree characteristics. Note: Montmorency cannot be grown in SK, so comparisons are based on literature and observations in Ontario and BC. Evans is a sour cherry variety discovered in Edmonton, Alberta.

	over-the-row harvesting	tree height	Vigour	Suckering	Harvest time
Evans	no	> 4m	extreme	many	Late Aug
Montmorency	no	> 4m	extreme	variable*	n/a
SK Carmine Jewel	yes	2 to 2.5m	moderate	slight	late July/early Aug
SK7-7-5.8	yes	2 to 2.5m	moderate	moderate	late Aug/early Sept
SK7-19-27.6	yes	2 to 2.5m	very	moderate	early to mid Aug
SK7-21-16.3	yes	2 to 2.5m	slight	rare	early to mid Aug
SK7-21-31.0	yes	2 to 2.5m	moderate	moderate	early to mid Aug
SK7-32-19.1	yes	2 to 2.5m	slight	slight	late Aug/early Sept

* Montmorency is usually grafted onto rootstocks

Chapter 3. BLUE HONEYSUCKLE *Lonicera cerulia*

(other common names: sweet berry honeysuckle, edible honeysuckle, and honeyberry)

When blue honeysuckles were planted in 1997, it was to satisfy curiousity and to determine if there might be any value in growing them. Little is known in North America about growing or breeding blue honeysuckles since this is crop is native to Siberia and Northern Asia. Russia began breeding improved varieties in 1950 but only a handful of older varieties are offered in North America. The Canadian "Sweetberry Honeysuckles" which have been around since the late 40;s have a bitterness that the Russians have bred out of their selections.

The U.of S. and Oregon State University (Dr. Maxine Thompson, retired) are the only institutions investigating Blue Honeysuckles in North America.

Here is a summary of what we have observed:

1. Early harvest season is 2 weeks before strawberries; the 1st fruit to ripen in SK!
2. Flowers can take -7C without damage (lab test with Karen Tanino)
3. Seeds are similar to Kiwi fruit seeds, you don't have to remove them and you don't notice them
4. They are easily detached and undoubtedly can be mechanically harvested. In fact they are the easiest to detach of any fruit I've encountered.
5. Flavour is sweet/sour with a hint of black current. Some people imagine them to taste like a blueberry but I don't think so. It is likely that they can be used in products similar to uses of blueberries.
6. Plants can bloom one year after planting.
7. They seem to be remarkably cold hardy. We have not seen any damage on the original 4 varieties planted.

Differences between varieties

In 1997, the 4 varieties planted were Blue Belle, Blue Bird, Blue Velvet, and Berry Blue. Blue Belle had a sweetness that the other varieties lacked but had poor tree shape (see Figure 3.1). Berry Blue had the best tree shape (see figure 3.2) but seemed a bit tart, which might be desirable for processing. Blue Bird seemed bland in comparison to the other two. Blue Velvet bloomed too late to be cross pollinated and had negligible yield. Two different varieties that bloom at the same time are needed for cross pollination.

Figure 3.1. Photo of Blue Belle. This variety is more compact and weeping and may be more difficult to harvest as the fruit is close to the ground.

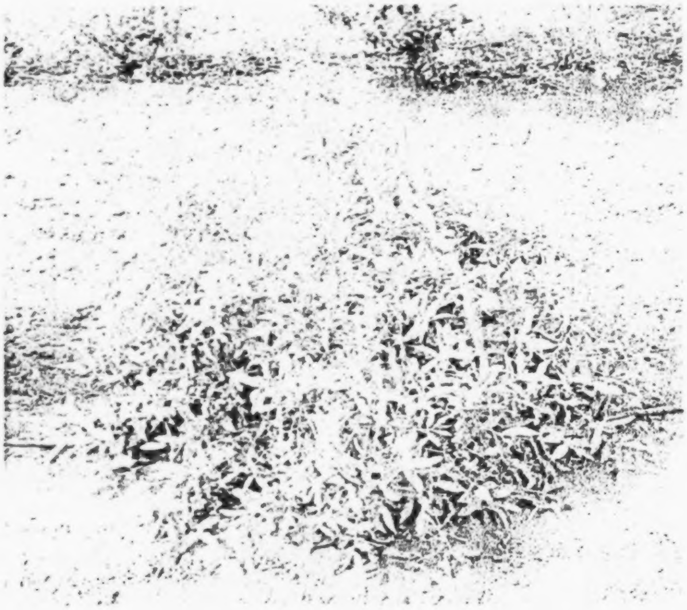
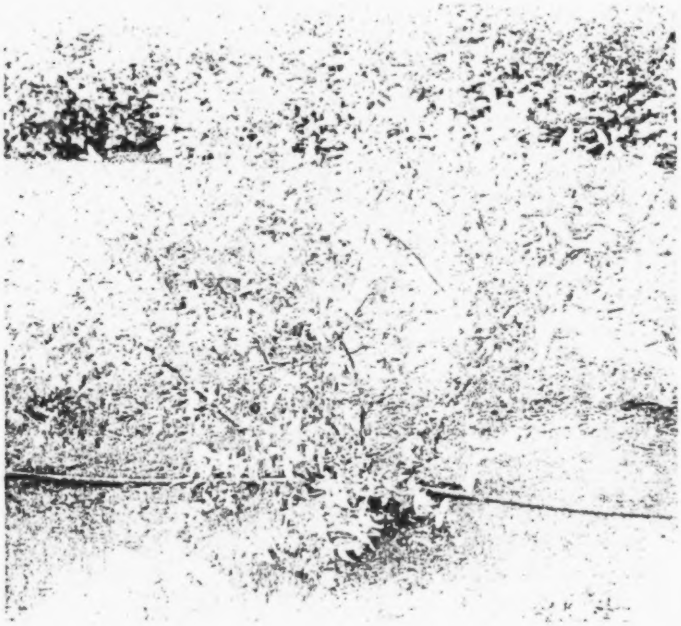


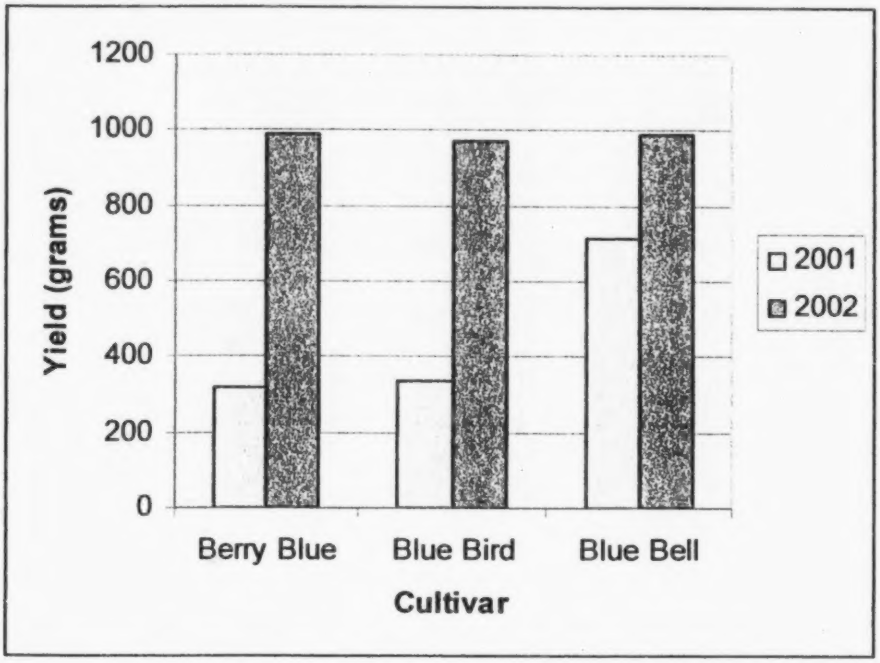
Figure 3.2. Photo of Blue Belle. Note upright growth habit that should be better for mechanical harvesting.



Blue Bell had double the yield of the other two varieties in 2001, but yield was similar for all 3 in 2002 (see figure 3.1). It may be possible that the early yielding characteristic of Blue Belle is related to its weeping habit. It is a well demonstrated principle in fruit training that horizontal branches tend to be more productive. Jim Gilbert (who sent the plants to us) saw the yield data from 2001 harvest. He was quite surprised and thought that our yields are much higher than what is possible in Oregon. He seemed to think that the US was too warm for this crop and mentioned that late frosts were a major problem in his area.

Fruit ripening was very uniform and the fruit were extremely easily detached. We had wanted to take pull force measurement similar to what has been done on the dwarf sour cherries but the fruit fall off with the slightest touch when ripe. These factors indicate potential for mechanical harvesting. It was also noted that no winter injury occurred on any of our bushes.

Figure 3.3. Yields of Blue Honeysuckles in 2001 and 2002. Only two bushes were planted of each variety, so this should be considered preliminary data.



The 3 productive varieties had very similar elongated appearance while Blue Velvet had an oval shape (figure 3.3). Blue Belle's fruit was slightly larger than the other 3 productive varieties (figure 3.4). Blue Velvet was not measured for fruit size since it was hand pollinated and did not have as many fruit to weight.

Figure 3.4. Four varieties of Blue honeysuckles (Left to right: Berry Blue, Blue Bird, Blue Belle, Blue Velvet) and fresh Florida blueberries.

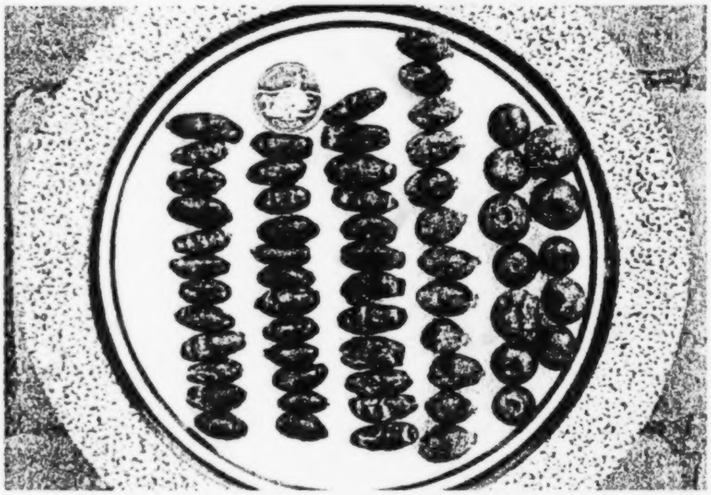
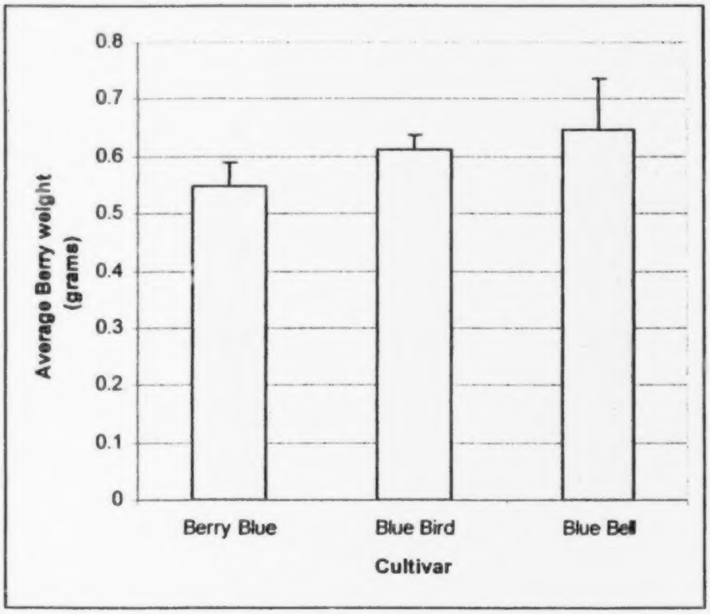


Figure 3.5. Average fruit weight of three varieties in 2002. Based on 8 reps of 50 fruit.



Of these 4 varieties, Blue Belle is the best for early yield, larger fruit and better flavour. Berry Blue is recommended as a pollinator, while Blue Bird and Blue Velvet are not recommended.

Data from the observation trial indicates that Sweet Berry Honeysuckles have potential for Saskatchewan and that further investigation is warranted. A yield trial with many more bushes in several locations would be desirable. Potential for mechanical harvesting needs to be investigated and training methods developed. Unpruned honeysuckle bushes are dense, which might be difficult for over the row harvesters. It might be possible to shape the bushes with a bush saw or hedge clippers.

New Germplasm

In 2002 we obtained 15 cultivars from the Vavilov Institute in Russia (a government genebank mainly open to researchers), and 20 seedling lines from the USDA genebank. These exist as small plants in our greenhouse and are being propagated for further testing. Fortunately, Blue Honeysuckles often bear fruit one year after planting so it may be possible to quickly pick out the best tasting varieties, but more time will be needed to determine productivity.

Blue Honeysuckle Seedlings

Approximately 850 seedlings and clones were planted in block six in 2002. These were from open pollinated seeds of the 4 varieties we have had in our collection for 5 years. Also included was a controlled cross between our late blooming variety, 'Blue Velvet' and our best tasting early variety 'Blue Belle'.

We have noticed is that blue honeysuckle seedlings are much more vigourous than cuttings from named cultivars. It may be that the named cultivars from Russia are derived from mature tissue and that this adversely affect the growth rate. Cuttings taken in 2001 from the mother plants would not elongate after rooting and went dormant but the seedling grown that year in the greenhouse would have been about a meter tall had they not been pruned back.

The seedlings in the greenhouse are variable in leaf size, shape, pubescence and vigour which suggest that ``fruit quality could be variable. In most cases, the 1st years growth was one or a few shoots growing straight up with little branching. On potted trees most buds broke along the initial shoots thus creating a nicely-shaped, fuller bush. in the second year.

We are growing a limited number of seedlings for testing by growers. Until such time that superior adapted cultivars have been identified and are readily available, seedlings may be a way to get to know this new crop. Perhaps the seedlings would be the best to experiment pruning methods on or to check for adaptation.

Chapter 4. HAZELNUTS *Corylus hybrids* (also called Filberts)

Objectives

Our broad objectives are to increase the genetic diversity of hazelnuts that are winter hardy in zones 2a and 2b and to make selections which are economically useful.

Background

Dr. Cecil Stushnoff collected some hazelnut from Honeywood Nursery, Parkside SK, in 1981 with the help of Dr. Bert Porter, the owner. These nuts were picked from bushes descended from Dr. Les Kerr's breeding work. Kerr combined the European hazelnut, *Corylus avellana,* with Manitoba's native hazelnut, *Corylus americana* at the Agriculture Canada research station in Morden MB sometime prior to 1960. Kerr had used mixed pollen of *C. avellana* sent from Geneva, New York, on plants of *C. americana.*

We planted the nuts from Honeywood Nursery in the University plots in 1982 and by 1989 we had identified several of the best genotypes. In 1991 Mr. Rick Sawatzky with the help of Dr. Karen Tanino made contact with Dr. Shawn Mehlenbacher, a hazelnut breeder at Oregon State University. Sawatzky and Mehlenbacher co-operated in exchanging nuts from hardy Saskatchewan hazelnuts for pollen of three advanced selections of *C. avellana* from Oregon.

Sawatzky made controlled crosses by applying the pollen from Oregon onto the three best hazelnut genotypes on the University plots. Approximately 500 seedling hazelnuts resulted from this breeding work. They began to fruit in 1999 and are showing some very interesting and valuable characteristics.

Hazelnut Seedling Evaluation

We evaluated the nuts from 150 genotypes which were the first to bear among the controlled cross seedlings mentioned above. They are segregating for good levels of winter hardiness with most being moderately hardy and some being very hardy. We will need more time to assess winter hardiness thoroughly. Data for those accessions which produced over 20 nuts is in Table ???. As these seedlings are just beginning to reach bearing age, yield cannot be adequately assessed. However, there is good segregation for various nut quality characteristics independent of hardiness and this is very encouraging. For example the percent kernel characteristic of Barcelona, an important commercial cultivar in Oregon and a standard for quality, is 44% of total nut weight. Oregon's best advanced selections are 52% kernel. The Kerr genotypes that where used as the female parents are in the range of 22% to 25% kernel. The controlled cross progeny vary from 23% to 50.5% kernel with 1/3 of the seedlings bearing nuts measuring above 40% kernel. The percent kernel characteristic is a measure of shell thickness and filling quality of the nut.

Percentage of full nuts is a characteristic for which our progeny were outstanding this year. This seems to indicate excellent fertility characteristics in our gene pool. The Oregon data that we have shows percent full ranging from 86% for Barcelona to 92% for OSU 313.078 selection. Our seedlings range from 33% to 100% full with 89 seedlings counting above 86% full and 63 seedlings counting over 92% full.

Another important characteristic especially for processing nuts is kernel blanching ability. When the gray/brown pellicles, which cover the kernels, have been removed by forced hot air revealing the off-white flesh colour of the kernels, blanched kernels result. Mehlenbacher states that Italian processors pay a premium price for blanched kernels from the processing cultivar, Tonda Gentile delle Langhe (TGDL). Approximately 1/3 of our seedlings have TGDL in their parentage through OSU 313.017 which we used as a pollen parent. These seedlings are segregating for self-blanching which is blanching without hot air treatment. A portion of the pellicle from self-blanching kernels adheres to the inside of the shell upon cracking. We haven't researched the method and equipment necessary for doing hot air blanching but our observations on self-blanching indicate that our seedlings have excellent potential.

Our hazelnut genotypes have a smaller nut (ranging from 0.78g to 2.76g per nut) than Oregon's advanced selections which range between 2.5g and 2.8g per nut. Our best quality hardy seedlings average 1.44g per nut. This may not be bad news since the processing industry has no minimum size standard. Also, all of Oregon's 1991 advanced selections, based on data given to us, have smaller nuts than the standard named cultivars, Barcelona and Willamette. The processing industry may welcome even smaller nuts since they are more easily added whole into confectionery products such as chocolate and granola bars.

We are encouraged by the number of seedlings showing small plant size and precocious bearing habit. Many of our genotypes are bushes quite unlike the small tree forms, which are grown in Oregon. One of our objectives is to select for plant sizes similar to saskatoon berries and other small fruits, which are mechanically harvested by over-the-row equipment. The same mechanical harvesters can be used for all of these crops since the nuts are ready much later than the small fruit crops (with the possible exception of primocane raspberries). In Oregon the nuts fall to the orchard floor and are collected by sweeping equipment.

At this time we do not have any insect or disease problems with hazelnuts. In our experience, deer do not browse hazelnuts while feeding heavily on adjacent plantings of cherries, apples, plums and dogwoods.

Breeding work plans include crossing our own best quality small-plant precocious non-hardy genotypes with our best hardy small-plant genotypes. Maintaining small plant size and winter hardiness is the challenge.

After making quality assessments in 1999 (table 4.1) we cut down all but the best hazelnut bushes so these lines can intercross. It is expected that intercrossing this population will resulting in seedlings with great variability for tree size, nut quality, and hardiness as they are hybrids between SK adapted lines and Oregon breeding lines.

Observations, 2002

The hazelnut block suffered severe winter damage in the winter of 2001-2002. This may have been complicated by drought stress. It was very encouraging to see that a number of seedlings survived and fruited. Percentage survival was about the same for the *Corylus avellana* back-crosses as for the original hardy *Corylus americana* hybrid population. In other words, it seems as though we didn't loose hardiness in the back-cross to improve quality. This is good news. All of the nuts were collected and planted. The resulting seedlings will make a valuable population from which to make selections; some possibly for commercial production.

TABLE 4.1. Hazelnut evaluations

Accession	hardiness rating [Z]	nuts / bush [Y]	% nuts with kernels	mean nut weight	mean kernel weight	% self blanching [X]	% fibre attached to shell [W]	Comments
7-1-5.7	3	149	89	1.31	0.57	20	48	thin shell
7-4-25.2	1	116	92	1.18	0.51	90	75	
7-3-7.3	2	115	90	1.34	0.45	90	17	thick shell
7-5-29.45	2	112	79	1.15	0.33	0	9	
7-3-22.1	1	76	82	1.49	0.49	52	60	thick shell
7-3-5.65	2	73	93	1.45	0.49	82	38	thick shell
7-2-7.2	**3**	**69**	**83**	**1.66**	**0.57**	**91**	**100**	
7-3-2.0	3	59	100	1.25	0.44	19	22	uniform kernel
7-6-11.1	**2**	**57**	**84**	**1.42**	**0.51**	**85**	**96**	
7-3-22.4	3	56	91	1.32	0.46	51	73	
7-5-19.0	2	50	90	1.36	0.48	44	62	
7-5-7.3	2	50	88	1.32	0.48	86	41	
7-3-31.9	3	47	83	1.56	0.73	26	82	dark attractive shell
7-3-13.4	2	44	89	1.05	0.43	77	3	
7-3-15.4	2	44	82	1.45	0.56	36	19	

Z: 1= winter damage noted, 2 = minor damage (may not be due to winter), 3 = no damage

Y: these numbers are not an indication of expected yield since these seedlings are just entering bearing age. However these numbers are a good indication of precocity

X: percentage of paper-like covering that attaches to the outer shell instead of the kernel

W: percentage of fibre that attaches to the outer shell instead of the kernel

Table 4.1. Hazelnut evaluations, continued.

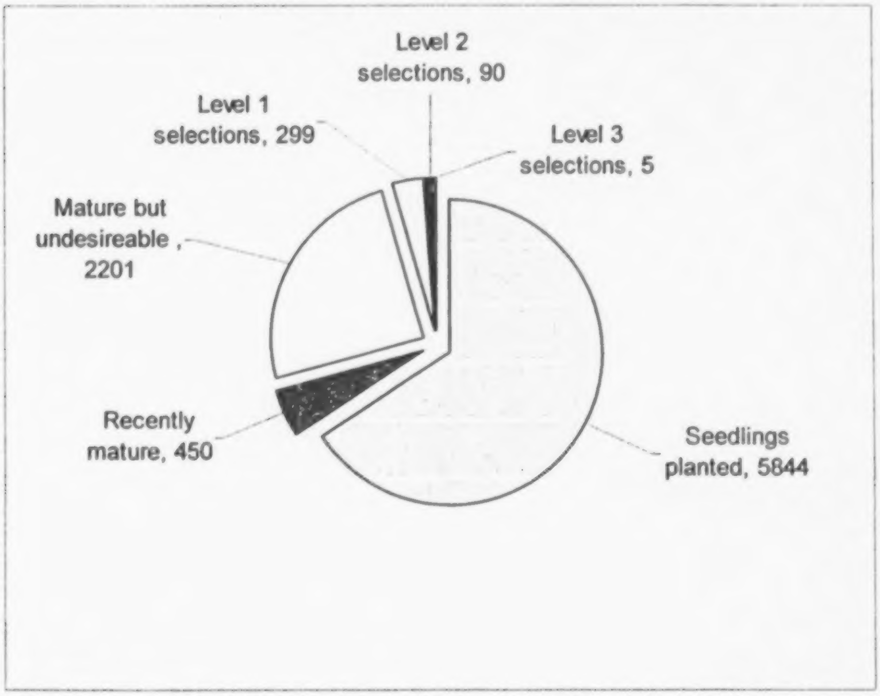
Accession	hardiness rating	nuts / bush	% full nuts	mean nut weight	mean kernel weight	% self blanching	% fibre attached to shell	comments
7-5-4.6	2	42	90	1.26	0.49	39	29	
7-1-14.15	2	41	78	1.52	0.56	38	56	
7-3-27.8	3	40	85	1.16	0.49	35	82	
7-3-3.6	2	40	93	1.17	0.39	49	43	
7-3-4.0	2	40	95	1.06	0.46	13	29	variable kernel
7-1-9.0	2	39	85	1.62	0.63	85	52	
7-1-19.6	2	36	92	2.08	0.68	70	91	thick shell
7-1-11.8	**2**	**34**	**68**	**1.63**	**0.60**	**83**	**83**	
7-1-8.7	2	33	79	1.43	0.51	0	23	poorly filled
7-3-17.1	2	33	94	1.20	0.38	58	23	
7-2-31.7	3	32	88	1.04	0.34	21	36	
7-3-1.7	3	31	97	1.23	0.51	20	87	
7-3-0.0	2	30	80	1.66	0.62	0	63	
7-3-17.75	3	29	90	1.57	0.57	69	58	
7-3-29.5	2	29	83	1.23	0.50	25	100	
7-1-6.4	3	28	79	1.42	0.53	9	64	
7-3-19.1	2	28	75	1.37	0.49	67	95	
7-4-30.0	2	28	100	1.03	0.45	57	25	
7-6-22.8	2	28	82	1.29	0.51	61	100	
7-3-21.4	**2**	**27**	**78**	**1.21**	**0.49**	**100**	**100**	
7-3-7.0	2	27	93	1.11	0.45	52	92	
7-3-4.6	2	25	96	1.32	0.53	67	38	
7-1-14.5	2	24	83	1.60	0.56	0	40	thick shell
7-6-10.0	1	24	83	1.36	0.44	50	25	
7-4-24.6	2	23	87	0.99	0.34	60	30	
7-1-22.9	3	22	73	2.13	0.71	0	75	thick shell
7-2-9.8	2	22	86	1.64	0.61	53	79	
7-3-13.7	2	22	100	1.08	0.38	64	55	
7-4-17.5	3	22	100	1.48	0.58	50	82	
7-1-4.0	3	21	90	1.38	0.45	0	21	
7-2-31.3	3	21	95	1.44	0.60	35	50	
7-2-12.8	**2**	**20**	**95**	**1.48**	**0.55**	**74**	**95**	
7-2-28.6	2	20	90	1.60	0.68	17	83	thin shell
7-2-6.0	2	20	85	1.40	0.38	35	71	thick shell, poorly filled
mean	2.2	43	87	1.38	0.51	47	57	

Chapter 5. APPLE *Malus species*

Seedlings and selection

Figure 5.1 summarizes the planting of new apple seedlings and number of seedlings that have undergone various levels of evaluation during the last 4 years. All of the seedlings in our apple breeding both old and new plantings are the result of controlled crosses and thus represent the planned combining of parents deemed to have complimentary characteristics. In 1999, there were 3045 seedlings that had been planted in the 80's and early 90's. Except for 450 trees in block 4, the older seedlings have been extensively evaluated over a number of years. All of the 'Mature but undesirable' and many of the level 1 selections have been removed while level 2 and 3 selections have been propagated for further study. Perhaps twice as many apple seedlings have been planted in the last 4 years than in the prior decade.

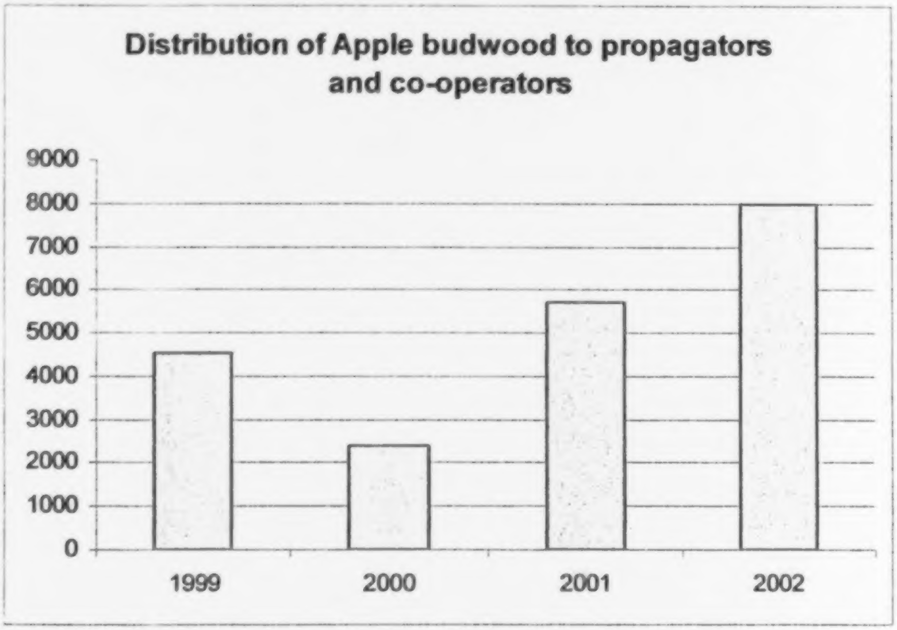
Figure 5.1. Number of apple seedling in various categories for breeding purposes, 1999 to 2002



Our selection strategy was as follows: Seedlings that had acceptable fruit quality and minimal or no winter damage were noted and field notes were taken (Level 1). If after a few years a tree was had consistent production and quality, fruit would undergo cold storage and evaluation. If found superior, it would be upgraded to level 2. Level 2 selections were propagated onto dwarfing rootstock and planted into a production field where regular training, pruning, spraying and fruit thinning would occur. Budwood of these would also be sent to co-operators for testing. When level 2 trees in the production field bear fruit, extensive taste tests were done. What we consider to be the best 5 selection based on all previous experience we categorize as level 3 selections. Level 3 selections are then more widely distributed to co-operators.

Prior to 1999 advanced selections were propagated and given to about a dozen co-operators and the number of apple trees distributed each year ranged between 100 and 200. In 1999 it was decided that we would no longer distribute trees. Instead, we began hosting grafting workshops and began distributing budwood to co-operators. The result was that budwood for 20,671 apple trees has been distributed to growers (see Figure 5.2). While not all grafts take and some losses were reported due to lack of snow cover in 2001 or the drought of 2001 and 2002, it seems reasonable to expect that at least 15,000 of our test trees have been established

Figure 5.2.



While apple breeding has been ongoing since the 1920's, there had never been an investigation into what parents have been most important in the program. Since the ancestry had never been traced, it was unknown if our apple breeding program was based on a wide or narrow the germplasm base or if inbreeding was occurring in the program. The following section summarizes investigations into this area.

ANCESTRY OF APPLE SELECTIONS AT THE UNIVERSITY OF SASKATCHEWAN

Bob Bors
University of Saskatchewan, Dept. of Plant Sciences
Saskatoon, Saskatchewan, Canada S7N 5A8

(Note: this paper was presented at the International Society of Horticulture Science in Toronto in August of 2002. Originally presented as a poster, this paper will be published in an upcoming Acta Horticulture)

Abstract

Since the mid 1960's, 30,297 seedlings from controlled crosses have been evaluated in our apple breeding program. Young seedlings were selected following artificial freezing in a deep freezer or natural conditions in a nursery where -40C lows are common each winter. Only 8717 seedlings showed superior cold hardiness and were selected for field planting. From this population, 68 advanced selections have been propagated for further study. The most important parents for producing advanced selections were Brookland and Haralson, which contributed 28.4 and 23.7%, respectively. Tracing ancestry revealed the most important founders to be Heyer 12, McIntosh, Ben Davis, and Malinda which contributed 17.6, 14.6, 12.2, and 11.8%, respectively. An additional 13 founders contributed 20.85% while up to 11 accessions contributed 22.9% through open pollination. Nine of the 51 cultivars developed through the Prairie Fruit Breeding Co-operative contributed 66% of the genepool. The twenty cultivars developed at the University of Saskatchewan between 1923 and 1960 have not resulted in promising offspring and make up only 0.4% of the genepool of advanced selection. Wild species have contributed less than 2.0% while cultivars of Russian origin contributed 23.8%. 56 of the advanced selections are third generation crosses while 12 are forth generation. None of the advanced selections have inbreeding in their lineage. Hardiness and fruit size was emphasized in previous generations. In the current generation those two attributes are more common and selection has been for fruit quality and storage life.

Introduction

The apple breeding program at the Univ. of Saskatchewan takes place in Zone 2 and is probably the coldest location in North America where apples are bred at a public institution. Identifying the founders and parents of advanced selections could be useful for others breeding apples in cold climates and for broadening the genetic base of prairie-hardy apples.

Materials and methods

Over the last 15 years, 68 advanced selections were selected from the apple breeding program at the University of Saskatchewan. Much of this material resulted from crosses since 1960 by either S. H. Nelson, C. Stushnoff, or R. Sawatzky at Saskatoon. The University of Saskatchewan also received seeds and seedlings from the Prairie Fruit Breeding Co-operative, of which it was an active participant (Ronald, 1978). Records showed that 30,297 seedlings were grown but only 8717 plants were field planted for fruit evaluation. Screening for cold hardiness was done in a nursery that commonly had -40C lows each winter or with artificial freezing tests (Stushnoff,1982). Advanced selections were chosen based on cold hardiness, productivity, and fruit quality.

The ancestry of U. of Saskatchewan advanced selections was compared to earlier lists of recommended varieties for the Canadian prairies (Saunders,1911; Patterson, 1936; Patterson, 1960; Ronald, 1978). Lineage was traced using various references (Anonymous, 1991; Beach et. al., 1905; Downing, 1870; Patterson,1936; Thomas and Wood,1897) to obtain a list of founders and intermediates. The founders were classified according to origin. A Microsoft Excel (version 97 SR-1) spreadsheet was used to calculate percentages and generate graphics.

Results and discussion

The ancestry of the advanced selections from the University of Saskatchewan could be traced to 15 cultivars and two wild species with a 23% contribution from open pollination (Table 1). An additional 25 cultivars had been intermediate parents with Brookland and Haralson providing the largest contribution to the genepool (Table 2).

Many selections from the U. of Saskatchewan breeding program have been derived from releases from the Prairie fruit breeding co-operative. Very few have lineage derived from earlier U. of Sask. varieties. While all recommended apple cultivars in 1911 had wild species as one of their parents (Saunders, 1911), wild species contributed less than 2% of the germplasm for current selections (Fig. 1.).

Russia is the only European country to which Prairie apples of any era could be directly traced. It seems likely Russian cultivars were preferable to wild species or crabapples as a source of cold hardiness in breeding programs. As domesticated apples are not native to North America, the apples that originated in Canada or the US may have their origins from other European countries. Earlier introductions of Russian cultivars had poor keeping quality (Beach et al., 1905) and it is generally known that older prairie apples varieties also have a short storage life. It seems likely the founders from chance seedlings and open pollinations were a source of improved fruit quality for more recent advanced selections. This could explain the increased importance of founders from North America.

Acknowledgements:

Funding was provided by Saskatchewan Agriculture and Food. Rick Sawatzky extensively evaluated the seedling orchards from which advanced selections were chosen and provided information on lineage.

References

Anonymous. 1991. Edible Apples in Prairie Canada. Pub. by The Friends of the Garden, Univ. of Alberta Devonian Botanic Garden, Edmonton, Alberta.

Beach, S. A.; N. A. Booth, and O. M. Taylor. 1905. The Apples of New York. Volumes 1 and 2. J. B. Lyon Company, Albany.

Downing, A. J. 1870. The fruits and fruit-trees of America. John Wiley and Son, New York

Patterson, C. F. 1936. Hardy Fruits. R. and R. Clark Limited, Edinburgh, Great Britain.

Patterson, C. F. 1960. University of Saskatchewan fruit introductions 1959-1960 unpublished manuscript.

Ronald, W. G. 1978. Prairie fruit breeding co-operative (PFBC). Reports of proceedings of 34th annual meeting of the Western Canadian Society for Horticulture: 63-68.

Saunders, W. 1911. Progress in the breeding of hardy apples for the Canadian Northwest. Dominion of Canada, Dept. of Agr., Central Experimental Farm, Ottawa, Canada. Bulletin no. 68.

Stushnoff, C. 1982. Selection for cold hardiness in fruit crops based on mechanisms of low temperature survival Breeding, in North America. Rep. Proc. West. Can. Soc.Hortic. Banff, Alta., The Society. 38:112-115.

Thomas, J. J. and W. H. S. Wood. 1897. The American fruit culturist. William Wood and Company, New York.

Figure 5.3. Origin of founders of prairie apples of different eras. Based on Saunders (1911),Patterson (1936, 1960), Ronald (1978) and advanced selections of the University of Saskatchewan fruit-breeding program.

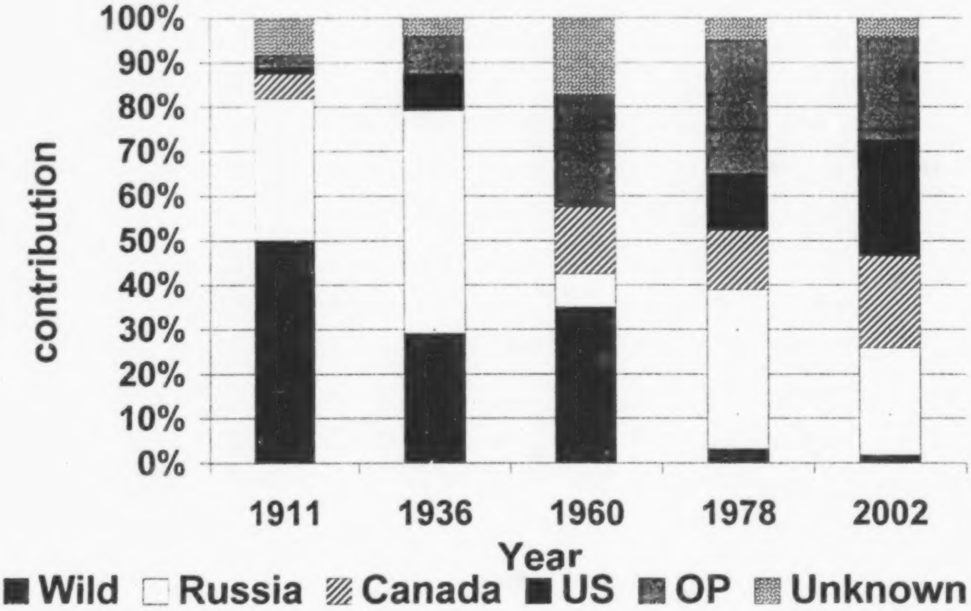


Table 5.1. Founders of recent advanced selections at the University of Saskatchewan.

Founders	% contribution
Open pollinated	23.1
Heyer 12	17.6
McIntosh	14.6
Ben Davis	12.2
Malinda	11.8
Lankford Beauty	4.2
Blushed Calville	3.8
BE6027	3.0
Duchess	2.5
Minn#1527	1.7
Pioneer #60	1.5
M. robusta	1.4
EE1-2	0.8
Lasiuk#2	0.8
Golden Reinette	0.4
Grimes Golden	0.4
M. baccata	0.3
Broad Green	0.3

Table 5.2. Intermediate parents of recent advanced selections of the University of Saskatchewan.

Parents	% contribution
* Brookland	28.4
Haralson	23.7
Lobo	9.1
Melba	8.5
* Westland	6.8
* Goodland	6.4
Rescue	6.1
* Norland	5.3
* Morden #359	4.5
* September Ruby	3.8
SK Prairie Sun	3.8
Dr. Bill	3.4
Minn #1728	3.4
Patten Greening	3.2
* Parkland	3.0
Wealthy	2.8
Melred	2.3
Patten	1.7
Breakey	1.5
Honeygold	1.5
* Pioneer #10	1.1
* 58-303	0.8
Golden Delicious	0.8
Wedge	0.8
Columbia	0.4

* Cultivars from the Prairie Fruit Co-op Program

Field Notes and Data Base

A 26-page document was created in 2000 which summarized field observations since 1995. In subsequent years, additional selections and observations were added. Table 5.3 depicts three pages of this document. Field notes are taken throughout the harvest season which generally runs from early September to early October. With apples, light frosts do not adversely affect fruit quality, and there is much variability in ripening time for various genotypes.

Field observations were further condensed into table 5.4 for up to 22 characteristics. This table has been given to co-operators to aid in the selection process and assist them in evaluation of the test selections they are growing. Of particular value to the growers has been season of ripening, storability, end use, and quality characteristics.

Table 5.3: Field Observations of Apple Seedlings

Seedling #	Observations
4-1-47pear	***11Oct00 v. edible sweet fruit. 26th still good!!!
4-2-50pear	11Oct00 was good
4-3-50	1995{stroked?, late red apple on tree, edible Oct17} 11Oct00 large red late attr apple. still ok see earlier nest year
4-4-18	11Oct00 some gf apples not bad
4-4-35	1995{stroked, NGE, Sept7-sour, seed 1/2 brown, size Ok, flav. sl. strong but Ok; Sept11-seed 1/2 brown, greenish flesh; Sept18-seed dark brown, no g.f. crisp, juicy, seems sl. immat., norm. br., 16% s.s; Sept25-sampled, sl. darker cream flesh around core, flesh chewy sweet, core good, br. quickly, 16% s.s.; Oct2-90% fallen, firm; Oct10-95% fallen, med. firm, v. edible, passed cooking with 2(firmer than 70-20-01) white} 1996{Jan12-soft, but good flav., low acid, sample out} 1997 *** 10% wk4, 20% sparse maybe due to insects, 10 Sept seed 1/2 br. good tex. 17 Sept excellent flav., excellent texture, will size up, seed br., sample, 13.5% ss average sized closed core, 30 Sept fallen fruit still v. good
4-4-35	1999 20 Sept sampled, questionable size flavour hardiness, rough fruit, poor colour; sample lost
4-5-14	1995{good core, size, flesh; Aug28-good size, core, flesh, ripe soon; Sept1-seed brown but wait(flesh not ready), sweet and starchy, br. resist. 16.5% s.s.; Sept5-sampled, excel. core, good size, single on spurs; Sept18-tough skin, 80% fallen, but still good; Sept25-g.f. and fr. on tree still good, med. firm and chewy, sl. ast., keeps well; Oct2-soft, try cooking; cook result 1.5}1996{Jan6-wilted, soft but quite edible, nice flav., marg. for panel; Jan23-in good in storage category*; Jan31-waxy firm, sweet, good acid, flav. Ok} 1997 no fruit 40% dead
4-5-14*	1999 7 Sept sampled, nice, small core, crisp, juicy, great flavour 27 Sept fallen apples still in good condition; 4 Oct fallen apples soft 28 Oct OK a few soft fruit, pink colour. 18Jan00 pressure test 7.9, 8.2 5Sept00 seed almost br. sampled. 11th still firm cr juicy sw. good tree 20th v. poor colour and soft, Nov16 flav. good, sl. soft 8.6 8.4

Table 5.3 continued: Field Observations of Apple Seedlings

Seedling #	Observations
4-6-30	1995{stroked, Aug29-ripe soon, fr. may not size up, size marj; Sept1-small open core, med size, seed 2/3 br; Sept7-tender crisp juicy, slow to br., very productive, good brown resistance, bright pink-red over greenish cream; Sept11-sampled, seed 5/6 brown, flesh sweet, flavourful, seems immat. flesh; Sept18-20%fallen and soft; Sept25-fallen, variable some soft, some Ok; Oct2-soft; cook-0} 1996{Jan15-scalded and beginning to rott., open core, coarse br. flesh, out} 1997** 4 Sept sample, seed 1/2 br., attractive 40% pink/red blush and light stripe over greenish cream, will size up v. nice v. hardy tree, size potential looks much better this year than in 1995. 10 Sept sample, falling, white flesh , v. good flavour, good fine crisp tex.
4-6-30*	1999 7 Sept very large fruit, very attrative, very hardy tree, good texture and flavour, sampled; 10 Sept picked all fruit on tree, fallen fruit soft 28 Oct storage sample out, dark red colour 5Sept00 mildew symptoms on folliage but none on fruit wiz v. attr and sizing well, sampled. 11th fruit soft 16Nov 9.2 8.1 soft attr good flav. proped 2000
4-6-46	1994**{Sept1-close, nice core, adequate size; Sept 13-picked; Sept28-still firm on tree; rated as a top apple from Nov-Dec taste panel, brown near core, firm, juicy, not crisp, v. nice flavor} 1995*{Jan5-firm, juicy, not crisp, br. near core, v. nice flavor; Mar20-firm, juicy, not crisp, sl. br. near core, v. nice flavor, good appearance; v. good size and color, large smooth attrac fruit excel, brown badly when green; Aug28-cooking?, good size and color; Sept5-dev. v. nice flav and a few fallen, br. sl. resistant, excel. core, keeps well; Sept7-slightly astringent otherwise incipid, tender crisp and juicy, wait, may develop flavor; Sept11-sampled, ?too late, beginning to fall, didn=t build up s.s. and flav this yr, flesh getting soft, good aroma; Sept18-30% fallen, still good; Sept25-marj firm and edible on tree and g.f.; Oct2-marj. firm and edible g.f., keeps well, cook-1, no color}1996{Jan12-firm, waxy, chewy, grassy flav., sample out; Jan15(Sept11 sample)-most apples no wilt, no wax, firm, not crisp but juicy, mild unique flavor, pretty astr., but little sugar and acid left, NGE for panel, out} 1996 field note: a few fruit1997* fruit size excellent for conditions 10 Sept first sample seed br. and beginning to fall, 17 Sept second sample, fruit hanging tight, birds have knocked off some, picked tree, nice crop, small closed core 12.7% ss

Table 5.3 continued: Field Observations of Apple Seedlings

Seedling #	Observations
4-6-46	1999 7 Sept seed brown but sour this year 13 Sept seed brown, sweet, 50% fallen, sampled 28 Oct storage OK, Bob had chucked it, pink/red striped and bruising. 18Jan00 Pressure test 7.7, 7.8 11Sept00 hanging well -had made crosses on it this spring 20th hanging well but soft and ? flav. no sample fr. sdlg tree. 2Oct many still on tree soft. sampled fr from blk4. 16Nov 17.2 16.1 ext. firm crisp and juicy flav ok. Forrest scored it excellent in all characteristics. Bob found the flav not great w an off taste.
4-6-47	1994{stroked?, water core, sl. small for cooking} 1995{stroked, too small for cooking, water core, core large} 1997 seen earlier and not good, stroked
4-6-48	1994{stroked?, astringent, (>95-size Ok, not too astringent)} 1995****Craig{tree excel., size Ok, white flesh, good core, too astr.?, at least mod. astring., beautiful red 90-100% wash/stripe with sl. cream white flesh, keeps; Aug28-astringent; Sept18-70% fallen, but sweet, v. crisp and juicy, sampled, nice aroma sl. to br., 13% s.s.; Sept24-picked for home, good condition, 13.25%; Oct2-g.f. wilted but v. crisp, seems too sour, but check later; this could be an excel. salad apple} 1996 {Jan23-in very good in storage category***, exceptionally good in storage, extrememly crisp and juicy as if just harvested sweet good flav. ast. just right for me; March8-still great}**16 Jan no wilt slight wax, firm very crisp, juicy, v. good flavour, salad apple, excellent colour, stores extremely well.
4-6-48***	1999 7 Sept sizing well this year, seeds half brown 13 Sept favour and colour building up but still no soluble solids, wait 20 Sept 10% fallen, first sample 27 Sept 90% fallen, firm crisp and juicy, very good size shape colour and flavour, second sample; 4 Oct 95% fallen, same 28 Oct both samples firm, pink colour. 18Jan00 Pressure test variable 11.2, 14.0, 10.8, 14.8 20 Sept sample storing very well, spongy and juicy. ***11Sept00 did crosses on it in spring. 40% fallen sampled good size considering the v. heavy crop 2Oct all fallen still good crisp juicy. v.good 100% red stripe wash over light green **v. attr**. 11Oct many gf still crisp juicy excel aroma. some frost damage but v. good compared to most. 16Nov 113.0 12.8 v. crisp juicy flav ok. Bob: >v. crispy good tex. unusual good aromatic quality.

Table 5.4. Brief description of apple selections and cultivars

EXTERNAL FRUIT CHARACTERISTICS

Size: small (< 6.5 cm), medium (6.5-8 cm), large (> 8 cm)

Shape: round, oblate, conic, oblique, oblong, ribbed, rough

Cavity and Basin: shallow, medium, deep, wide, narrow **Stem:** short, medium, long

Calyx: open, closed **Skin:** smooth, prominent lenticels, thick, thin, waxy in storage

Over Colour of fruit: red, pink, orange, dark, light, stripe, splash, blush, bloom

Percent Over Colour: (a numerical value) *-attractive

Under Colour of fruit: cream, yellow, green, light, medium, dark

INTERNAL FRUIT CHARACTERISTICS

Flavour: sweet, sour, astringent, bitter after taste, aromatic, poor, fair, good, super

Uses for fruit: dessert, cooking, salad, juice, dehydrating, and poor, fair, good, excellent

Browning resistance of cut fruit: poor, fair, good, excellent **Core:** small, medium, large, closed, open

Fruit flesh texture: coarse, fine, breaking, crisp, juicy, soft, spongy, firm, tender, not, slightly

Flesh colour: dark, light, white, cream, yellow, green, red vascular tissue and/or near skin

Cooked flesh: firm, medium, soft, white, pinkish, yellow, cream, greenish, dark, light, bright

OTHER CHARACTERISTICS

Ripening Season: very early (before Aug 25), early (Aug 25 to 31), mid (Sept 1 to 10), late (Sept 11 to 20), very late (after Sept 20) fruit hangs on tree, falls easily

Storability of fruit: poor, fair, good, excellent

Tree hardiness and branching habit: poor, fair, good, excellent, hardy, not hardy

Vigour of tree: semi-dwarf, normal, vigorous **Mildew:** none, slight, moderate and severe

	External Fruit Characteristics										Internal Fruit Characteristics							Other Characteristics			
sel'n no.	siz	sha	cav	bas	ste	cal	ski	ovc	per	unc	fla	use	bro	cor	tex	flc	cfl	sea	sto	tre	vig
4-4-3	m										swg	gdgc	g	sc	fcrj		mw	l	g	nh	
4-4-35	m	o						or	90*		swg	gdgc	f	mc	fcrj	c	fw	l	fg	l	
4-5-14	m										swga	d	g	sc	crj			m	g	gh	n
4-6-30	l							prbl	90**	crg		d	g	so	crj	w	sw	m	p	gh	n
4-6-46	l				l			prst	*90?		fa	d	f	sc	fmj		m	m-lh	g	eh	n
4-6-48	m	c			m		w	lrsp	**95		gaar			mc	vcrj	cr/w		l	e	eh	n-v
4-8-41	sm							dr	*90	mg	swar	fd	p		sp			vlh	g	gh	m
4-9-3	vl													l				vl		gh	
4-9-14	m	c			l						susw		p	mo	fmsp	y	fy	vl		f	
4-9-43	l											df		lc			fw	m	f		
4-9-48	l							r	80		g	dg				g		m	f		
4-9-50	m										gar	dg			cr		mw	m	f	gh	
4-10-36	s/m				l			lo	1*	my	esw	d	g	sc	jfcr*	ly	sy	l/vlh	f	eh	m
4-10-43	s-m				l		w	dr	80*	lgy	swg	eds		om	crjsp	wrs	mpy	lh	e	e	d
4-10-48	s				l					y	vswg	dje	f-g	so	fcrj*	cy	fy	vlh	g	?h	v
4-11-16	m										swg						m	e	g	nh	
4-11-21 D	s	vr									s							m	e	h	
4-11-28	l							st			gsusw	gd		lc	fs			m	f		
4-11-44	ml							rwst	80**	gy	gsw	gdc	f	lo		wrv	fpw	vl	ge	h	l
4-12-8 D	l											fd								nh	
4-13-40	s										gsw	gd		sc	*			l	e	fh	
4-13-43	m							rst			gsws	gdec	e	vsc	fmcr			l	g	eh*	m
4-15-41	m	*						r	100*		esw*	ed			*			m		eh	m
4-15-50	m	*						r	100*		esw*	ed		vsm	crj			e		eh	

codes	siz	sha	cav	bas	ste	cal	ski	ovc	per	unc	fla	use	bro	cor	tex	flc	cfl	sea	sto	tre	vig	n
4-16-14	l										sw	gdgc	g	*	crjt		fw	m	g	h		
4-16-15 D																				nh		
4-16-26	m	*						orstp	60	lg	gsw	gd		*	*	bg		ml	g	gh		
4-17-23	m							dr	70	lg	gsw	gd		so	crj	w		lh		gh		
4-17-35	ml	**						y*		ly	sw s	fcfd			fb	c	dy	ml	f	gh		
4-17-49	l?							r	90*		gsw	gd						m	fg?	hl		
4-18-13	m							?str		yc	vsw	gd	g*	sc	*jcr	by		l		eh*		
4-18-21	m							r*	100*		gsw	gd			f?			l			mw	
4-18-42	m	*						r	90*	lg	gsw	gd	g		*			l			mw	
4-19-7	m	*						br	?80*	lg	gsw	gd			*			l		?		
4-21-46	m							obl	10	lg	gsw	gd			**			l		h	mw	
4-25-46	ml	?r						p	10	lg	gsw	gd		o	*			vl		?	mw	
5-1-64	m?							rst	*		gsw	gdgc		sc	*		fw	m	f	gh		
5-2-43	l							y	*		swsg	gdgc	g	sc	*			l	f	gh		
5-2-47	l							rbl	20*	cy	sg	gd	g	sc	*			l-vl	g	ghl		
5-2-52	m-l	c						rosp	50	lg	swsg	gd	g	so	crj	lg	y	l-vlh	g	ghl		
5-4-14	l	slr						psp	90*	lg	swb	df	f	lo	f			m	g	nh		
5-5-42	m							rpst	50?	lg	swg	gd			jcrj	lg	lg	l	f	h		
5-5-62	m	olr						rst		g	susw	gd			*			l	g			
5-5-79	ml	c						r	80*	dg	swg	fd			c	ly		m	p	h		
5-6-33	l	r						rst	?90*		swg	gd	g	sc	*	w		m				
5-7-22	m-l	c						lo	80	cg	swf	gd						ve	p	h		
5-9-33	l	c								cg	swf	fd	g	lo				e	p	eh	v	;
5-12-22	m									g	swsg	gd	g					m	g	nh		
5-12-23	m											gd										
5-15-41	l	c						r	100*	c	swf	fd		*		w		m		h		
5-18-8	m-l	rdr						dr	100*		susw	gd						m	f	gh		
5-19-7	m-l							r			swg	gd			f			em		gh		
5-19-13	m-l	r*						osp	5	y	swg	gd		mo	*			l-vl		fh		
5-19-20	m-l	c*						lr	95*	ly	swg	gdgc	g	mc	*	w	w	l-vl	f	gh	v	
18-1-2	m										sws	je	g			w		l	f	h		
18-2-22															f			l		l		
18-4-6	m-l							drsp		lg	sw	fd	p					m				
18-4-14	l	*					tk				swg	gd			s	w		lh		?hl		
18-5-18																		m				
18-5-27	s	r*			m		tk	rsp	20	g	swg	gd		mc	fcrj			l	g	h	d	
18-6-11	s-m	ot*						drsp		dg	swg	gd			fsp	lg		vl	g	fh		
18-7-9	s	*						r	80*	c	swg	gdj	p					lh	g			
18-7-10	l	*					tk								scrj							
18-8-9	s	rb						r	80		arg	gd		mc	scrj			m-l	g	fh		
18-9-8	m										swg	f-gd			fmcr	lg		l	g	fh		
18-10-1	m	*						dr	100*		atf	fd										
18-10-19	s-m							dr	100*		swg	gdj	f	mo	fmcr		my	lh	f	fh		
18-10-32	l	rdoq	m	w	s	c	sm	or	50	lg	swg	gd	g	smc	fmcr	w	s	m-l	g-e	gh	v	
18-11-5																		l				
18-17-3	m										swg	gd	g	smc	fmcr	w		vl	g	gh		
18-17-11	m-l	ot*						r	100*	lg	swsg	gd	g	sc	fmcr	w		vlh	g	gh	n	
18-17-24	m							dr	90*		swg	gd			crj			l				
18-17-25	s-m							rsp	40	cy	swg	gd			crj*			l	g	gh		
18-18-11	m-l										swf	fdjc	g	mo	fmcr		f	m	g	gh		

codes	siz	sha	cav	bas	ste	cal	ski	ovc	per	unc	fla	use	bro	cor	tex	flc	cfl	sea	sto	tre	vig	m
18-19-13	m	cr					tk	r	90*		Swg	gd	f	mo	crj			e-m	g	gh	v	n
18-22-23	m-l	ot*								c	Sws	gds	g	sc	crj*			lh	g	gh		
18-23-20	m										susw	gd										
18-28-1	l	c*						r	80*		swg	gd			scrj	w		ve	p	gh	v	n
18-28-19	l	r						r			swg	gd			scrj			ve	p	gh	v	
18-32-7	s-m						tk	r	70		swg	gd			scrj			m				
18-34-23	s-m							rsp	20		sws	fd			fmcr			m-l				
18-42-13	m										swg	gd						e		h		
18-49-34																		m				
21-52-22	sm										swg	gj	g		crj				f	fh	d	n
21-53-17	m										swg	gd						e	g	gh		
21-64-11	s-m	ot*						obl	5*	lg	swg	gd	g	sc	*	w		vl	g	fh		
Bibby	l							rst	20	g				lo				e	p	ph		
Brooklnd	s							rstsp	30	lg	swf	fd	g	sc	crj	w			f	gh		
Edith Sm	m							rsp	60	cg	swsf	pdfc		mo	cfm				f	gh		
CarlosQu	m	*						o	20	yg	swg	gd	g	sc	crj				f	fh		
Goodland	m-l	*						rstsp	30	cg	swg	gdc	g	sc	scrj	w			g	ph		
Haralson	m	*						drst	60	dg	swsg	gd	g		*	lg		vl	g	ph		
Honey-crsp	l	*						rbl	60*	cg	swg	gd	g	sc	*	c		vl	e	ph		
Min 447	sm							drsp	80	dg	swf	fdj			*	ly		vl	e	fh		
Minn 1728	m	*						r	90*	g	swg	gd	g							ph		
Parkland	sm							r	80*	lg	swg	fd								gh		
PF 47																						
PF 50	m-l	*						r	100*	c	sf	pd	g		Fm				f	fh		
PF 51	m	c						orbl	50	lg	swg	gd	g		*				g	fh		
SeptRuby	s-m	c						dr	90*	g	swg	gd			fmcr	lg			f	gh		
codes	siz	sha	cav	bas	ste	cal	ski	ovc	per	unc	fla	use	bro	cor	tex	flc	cfl	sea	sto	tre	vig	

G DISK A:APDESCR.TBL

Sensory Evaluation of stored Apples

It should be pointed out that we do not have controlled atmosphere conditions at the University, so our observations closely reflect results obtained with 'low-tech' storage. With proper CA storage, it is conceivable that shelf life could be doubled.

The goal of these evaluations is to screen our seedling for improved storability. Such results should be considered preliminary in nature. Larger numbers of fruit would need to be grown to full evaluate and predict conditions needed for our future varieties.

During this grant, the protocol for evaluating our stored apples has evolved. In early years, Rick Sawatzky would evaluate stored fruit after a few months in storage. By 2002/2003 taste panels were initiated in the plant Science department at the U of S and multiple dates of testing were done for some selection. Initiated in fall of 2001, we now use a Hedonic score sheet and do one sample at a sitting. This seemed to greatly reduce the influence that one sample has on the following sample. Larger samples were presented and this better represented eating an apple rather than nibbling.

Results of the various years follows.

Evaluation of Apples, winter 1999

The seedling apple orchard occupies an area of seven acres and contains about 3500 trees. From September 1st to October 4th, 1999 field notes were made on 151 apple seedlings that seemed to have good cold-hardiness and worthwhile fruit characteristics. Notes include such characteristics as fruit size potential, appearance, core size and shape, flavour, texture, and tree characteristics. Of these, 74 were sampled (some on multiple dates) and placed into cold storage at 3° C. [Note: cold storage was not with controlled atmosphere. This test is similar to conditions that growers might use for short-term storage]. Stored fruit was evaluated on October 28 for firmness, storage scald and rots. Also, 38 named cultivars and numbered selections from old breeding programs were also included.

Table 5.5 summarizes the best 20 seedlings as of October 28. Of the 38 reference samples nine were storing well, 14 were storing moderately well, and 15 were storing poorly. Many of the reference samples were picked at a slightly immature stage of ripening and, therefore, lasted better in storage than usual.
The selections with asterisks are sufficiently promising to merit propagation in 2000 for further testing. Some of these are early ripening selections with outstanding size, colour, and flavour but may need additional testing in storage. Two of these selections **(4-6-48** and **18-22-23)** have exceptional size and are very attractive. Co-operators have been expressing keen interest in growing such fruit for the early market and for promotional purposes.

Table 5.5. Best Apple selections after storage, 1999

Accession	Fruit colour	General Notes	Storage on Oct. 28
18-10-32*	red striped	80% fallen, sampled and the ground fall picked up; great as usual	OK
18-17-03	yellow	crisp and firm, sweet with a good favour	OK
18-19-09	dark red striped	very good flavour and texture, fruit will size, sampled, bright red stripe/wash over light green ground colour, rough shape, sweet, better than 18-19-06 but smaller	OK
18-19-17	red striped	sweet crisp but small fruit	OK
18-22-23***	slight speckled blush with yellow over cream ground, very attractive	excellent size shape core and texture, flavour good but not quite as sweet this year, excellent tree	Firm
4-5-14*	pink colour	small core, crisp, juicy, great flavour	OK a few soft
4-6-48***	pink colour	firm crisp and juicy, very good size shape colour and flavour	Firm
4-8-41	dark red	flesh chewy, very sweet, tight on tree few fallen,	Ok
4-9-43*	red striped	odd flavour, very large fruit	Ok
4-9-50	pink	good texture flavour very nice, good size, good tree,	firm
4-10-48	red striped	crisp, juicy, very sweet slight storage scald	very firm

Table 5.5. Best Apple selections after storage continued.

Accession	Fruit colour	General Notes	Storage on Oct. 28
4-11-16*	pink	nice flavour, sampled will size up	OK
4-11-44**	red striped	very low acid	OK
4-15-41*	pink	very good flavour, attractive red with white flesh, will size up	OK
4-16-26*	pink over yellow	very firm flesh excellent texture, excellent core, crisp, juicy,	OK
4-17-35**	yellow	extremely attractive large fruit, super sweet solid yellow no blush, coarse flesh, not crisp	OK
4-21-46*	yellow	exceptional excellent texture and good flavour, Mac Wijcik type, crisp/juicy, good flavour,	Ok
5-5-42	lighter red striped	good texture and flavour	OK, firm
5-6-33*	nice red striped	excellent texture and flavour	OK
5-19-13*	yellow	large smooth yellow, excellent texture and flavour, medium size, partly open core, chewy firm/crisp	OK

Storage Evaluation of Apple Seedlings, April 2000

A penetrometer test is a preliminary indication of long-term storage and is useful for identifying promising selections to be studied in the next season. The test was conducted in walk in refrigerator at 3° to 5° C. Apples were kept in cold storage until 18 January 2000 after which they were tested for firmness with a Magness-Taylor Penetrometer. Results of the test are listed in Table 5. A value of 12 or higher is considered acceptable for shipping per industry standards. The storage conditions did not use controlled atmosphere and thus were more severe than those used by commercial growers in most fruit growing regions.

Table 5.6. Penetrometer tests on University of Saskatchewan selection on 18 January 2000.

Selection number	Penetrometer reading (lbs)
18-22-23	13.2
18-23-20	13.1
4-16-26	12.7
4-6-48	12.0
18-19-6	11.9
4-15-41	10.1
18-19-17	9.8
18-17-03	9.5
18-19-09	9.2
18-10-32	8.7
4-9-43	8.3
4-11-44	8.1
4-5-14	8.1
4-11-16	8.0
4-21-46	7.7
5-6-33	7.3

Apple evaluation in storage, April 2001

We collected the samples in labelled paper bags and put the sample bags in polyethylene tubs for convenient handling. This year we decided to enclose each tub in a poly bag to prevent excessive desiccation of the fruit. Some holes were punched in the bags for ventilation and to offset condensation. There must have been ethylene build-up in the bags because the fruit didn't store as well as desired despite the temperature being at 0 ° Celsius. However, we were able to take some meaningful notes and do pressure tests. These data are contained in Table 5.8. This ethylene build-up caused off flavours so flavour evaluations listed below were based on fall evaluations done when the fruit was fresh. The anticipated increase in the incidence of storage scald at 0° C compared to 3° C did not materialize this year which could indicate scald resistance of our germplasm but additional years of testing at the lower temperature will be needed to make sure. There are reports of variability in this disorder due to growing conditions.

Table 5.7. Apple Cultivars and Selections Pressure and Sensory Tests in Storage 2000/2001. *Where multiple samples of the same variety are listed, different dates are listed.

Selection	Sample Date*	Nov 2000 Pressure	Flavour /Texture	Feb 2001 Pressure	Flavour /Texture
4-5-14		8.5	g/f	8.5	g/f
4-6-30		8.7	g/f		
4-6-46		16.7	f/e	same	f/e
4-6-48		12.9	f/e	same	f/e
4-8-41		-	-	10.3	f/g
4-9-3		10.7	f/p	8.7	p/p
4-9-14		15.9	f/p	14.5	f/p
4-9-43		8.9	f/f	8.5	p/f
4-9-48		9.0	f/f	8.8	f/p
4-9-50				5.0	p/p
4-10-10				8.6	f/f
4-10-14				7.7	f/p
4-10-43		16.0	g/e	same	
4-10-48		na			
4-11-16		9.1	f/g	gone	
4-11-21		15.6	f/e	16.0	f/e
4-11-28		10.3	p/p	out	
4-11-44		13.3	g/g	10.8	f/g
4-12-8		9.3	p/f	out	
4-13-43		na			
4-15-4		9.8	f/f	10.7	g/p

Table 5.7. Apple Cultivars and Selections Pressure and Sensory Tests in Storage 2000/2001 continued.

Selection	Sample Date	Nov 2000	Flavour /Texture	Feb 2001 Feb	Flavour /Texture
4-15-50	5Sept00	8.1	f/g	6.2	f/f
4-16-1		8.8	f/p	out	
4-16-14		na			
4-16-15		11.7	g/e	12.2	g/e
4-16-26		14.2	g/g		
4-17-35		11.8	f/f	10.0	p/f
4-17-44		8.2	f/p	out	
4-18-1		7.6	g/f	out	
4-18-13		10.2	g/g	gone	
4-18-42		11.8	f/f	11.8	g/f
4-19-7		10.6	g/f	out	
4-21-46			e/g	9.6	f/p
4-21-32		7.9	g/p	7.7	p/p
4-21-40		9.5	f/g	gone	
4-22-43		7.9	f/f	out	
4-23-40		6.6	p/p	out	
4-23-42		15.9	e/g	12.9	f/g
4-23-43		9.4	g/f	out	
4-24-31		8.3	f/p	out	
4-24-50		12.5	g/g	10.7	g/g
4-25-46		17.7	g/e	15.7	g/e
4-25-48		16.5	f/f	11.1	f/f
5-1-64		6.5	p/p	out	
5-2-41	5 Sept			8.3	p/p
5-2-43		soft	out		
5-2-47	8 Sept			16.5	g/e
5-2-52	22 Sept			7.9	f/g
5-4-14	8			10.4	p/p
5-5-42	12 Sept			10.1	f/p
5-5-62	5 Sept			9.9	g/g
5-5-79		soft	out		
5-7-22		soft	out		
5-9-33		soft	out		
5-12-22	30 Aug			16.0	f/e
5-12-22	6 Sept			15.3	f/e
5-12-23	5 Sept			15.8	ss,f/e
5-12-23	7 Sept			14.8	ss,f/e
5-15-41	31 Aug			7.8	f/p
5-18-8		soft	out		
5-19-7	31 Aug			6.9	g/f

Table 5.7. Apple Cultivars and Selections Pressure and Sensory Tests in Storage 2000/2001 continued.

Selection	Sample Date	Nov 2000	Flavour /Texture	Feb 2001 Feb	Flavour /Texture
5-19-13		na	na		
5-19-20	22	10.7	g/g	8.4	g/g
18-1-8				7.2	p/p
18-2-22				7.8	f/f
18-4-6		8.1	g/p	8.1	g/p
18-4-14		6.7	p/p	soft	out
18-5-18	11 Sept	miss	miss	10.4	vg/f
18-5-27				10.3	g/p
18-6-11		18.3	f/g		
18-7-9	14 Sept			10.8	g/g
18-7-9	20 Sept			9.5	g/g
18-7-10				7.5	p/p
18-8-9				7.7	vg/f
18-9-8		11.0	f/f	10.9	f/f
18-10-1		10.8	p/f	10.6	p/p
18-10-19	14 Sept			10.6	p/p
18-10-19	20 Sept			10.3	p/p
18-10-32	6Sept sdlg	8.8	g/g	7.6	f/f
18-10-32	8 Sept			9.4	vg/g
18-10-32	12 Sept			9.9	vg/g
18-11-5				8.6	g/f
18-17-3		13.1	g/g	soft	out
18-17-11		12.9	f/f	11.6	f/f
18-17-24		soft	g/f	8.4	g/f
18-17-25		9.0	f/f	soft	out
18-18-11		11.1	p/p	b pit	out
18-19-9		11.9	g/g	11.0	g/g
18-19-13	6 Sept			11.7	g/f
18-22-23				17.6	g/e
18-23-20		13.7	g/g	12.4	g/g
18-28-1		7.3	p/p	soft	out
18-49-34				7.9	f/p
21-52-22				9.7	p/p
21-53-17				8.1	g/p
21-64-11		13.7	g/g	11.5	g/g

Table 5.7. Apple Cultivars and Selections Pressure and Sensory Tests in Storage 2000/2001 continued.

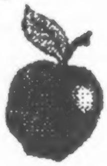
Selection	Sample Date	Nov 2000	Flavour /Texture	Feb 2001 Feb	Flavour /Texture
Bibby		soft	out		
Brooklnd		soft	out		
Edith Sm		soft	out		
Estonian				12.2	g/g
Carlos Queen				11.3	p/f
Goodland	bit late			7.4	g/p
Haralson	2 Oct			13.9	p/g
Honey-	14 Sept			17.8	g/e
crisp	2 Oct			17.1	g/e
M7820		soft	out		
Minn 447	2 Oct			14.6	f/g
Minn 1728	?	8.2	p/p	b pit	out
Parkland		soft	out		
PF 47				9.5	f/p
PF 50				12.0	p/p
PF 51				15.2	f/e
SeptRuby				12.3	g/p

Fruit Storage 2001

Fruit samples were collected into paper bags again this year but the samples were not enclosed in poly bags in storage. The storage temperature was set at 2.5° Celsius because of the tissue culture jars that are sharing the same storage room. A number of steps were taken to control foreign odours in the cold storage room. A shallow dish containing activated charcoal was placed in the room. Samples of plant material that had languished in the room for years were discarded. Root crop and vegetable samples were not allowed to share the same room. In 2001, a new score sheet was developed (Table 5.8). This new system was used by Dr. Bors, Rick Sawatzky and Forrest Scarff evaluate 45 apple selections. Fruit were evaluated one to three times by each person. Overall averages are shown in Table 5.9. This data was used primarly to narrow the list of promising selections (Table 5.10) in the following season.

Table 5.8.

FRESH APPLE SCORE SHEET



Name: ____________________

Date: ____________________

Apple Identification Number: ____________

A. Circle the number which represents your personal liking: (1 = worst, 8 = best)

1. APPEARANCE:	1	2	3	4	5	6	7	8
2. TEXTURE:								
Firmness (hardness)	1	2	3	4	5	6	7	8
Crispness	1	2	3	4	5	6	7	8
Juiciness	1	2	3	4	5	6	7	8
3. FLAVOUR								
Sweet/Sour Balance	1	2	3	4	5	6	7	8
Astringency (the dry grape tannin taste)	1	2	3	4	5	6	7	8
Aromatic Flavours	1	2	3	4	5	6	7	8

4. COMMENTS

B. Circle your favourite store-bought apple (one only)

Gala
Spartan
Red Delicious
Macintosh
Fuji
Granny Smith
Braeburn
Golden Delicious
Other____________

Eight-Point Hedonic (personal Liking) Scale (1 = worst, 8 = best)

1	Disgusting	5	Fair
2	Not at all enjoyable	6	Good
3	Not to my personal liking	7	Very good
4	Possibly acceptable	8	Just right for me

Thank-you for your help!

Table 5.9. Results of fresh apple evaluations, Fall 2001.

Selection	score	Selection	score
18-10-32	7.4	4-11-48	6
18-22-23	7.4	4-9-3	6
18-19-13	7.3	4-5-14	6
4-6-48	7.2	4-16-26	6
18-17-11	7	18-7-9	6
4-24-50	7	18-9-8	6
4-10-43	6.9	4-18-42	6
18-5-18	6.8	4-18-13	5.9
5-19-20	6.8	18-1-2	5.8
5-4-14	6.8	18-2-22	5.7
5-2-47	6.7	18-34-23	5.5
21-64-11	6.6	4-21-46	5.5
Carlos Queen	6.5	4-6-46	5.3
4-11-44	6.5	18-17-3	5
5-2-52	6.5	21-52-23	4.7
4-13-43	6.4	18-19-13	4.5
4-4-13	6.4	4-10-36	4.4
Norkent	6.3	21-76-31	4
4-25-46	6.3	18-12-25	4
		18-32-7	3.7
		4-19-47	3

Point Scale
1. extremely unaceptable
2. very unacceptable
3. unacceptable
4. slightly unacceptable
5. slightly acceptable
6. acceptable
7. very acceptable
8. extremely acceptable

Fruit Storage, Fall 2002

We collected larger apple samples this year to give us enough fruit for a larger sensory panel on two dates and for one fruit per panellist.

Fruit samples were held in paper bags at 0° C instead of 2.5° C as they were last fall. All other conditions including sanitation and exclusion of other crops remained the same. This worked very well since the fruit remained in very good condition and only a few selections showed severe storage scald.

As this grant expired in Nov of 2002, there was not enough time or funding to fully evaluate the stored fruit. Evaluations were done in early 2003 but will not be included in this report.

Table 5.10. Most Promising Apples, 2002

Selection	Description
4-6-48	Ripens near September 16. This is a very attractive apple with skin nearly 100% bright red over a light green ground colour. It is of medium size with creamy-white flesh. The flavour is neither sweet nor sour and has an excellent aromatic component. There is just the right amount of astringency (as in the pucker of good table grapes). It has an excellent crisp-juicy texture and the storability and shelf life are excellent.
4-10-43	Ripens near September 12 but hangs well on the tree for at least two weeks. The skin is mostly red and the flesh is white with attractive pink staining near the skin. The fruit is of small to medium size with an excellent sweet flavour and an excellent crisp juicy texture. Storability and shelf life are excellent. The tree is very hardy.
5-2-52	Ripe near September 20. This is a large conic shaped apple with a 50% light red wash and blush over a light yellow ground colour; very attractive. The flesh has a firm, crisp and juicy texture and is very resistant to oxidative browning. The flavour is rich, slightly tart and much like a well-grown Granny Smith.
18-10-32	The ripening date is variable around September 15. The fruit is large, smooth and attractive and somewhat asymmetrical in shape. The skin colour is 50% orange/red wash and stripe over a light green ground. The flavour is sweet with exceptionally good aromatics. Sensory panellists have twice preferred the flavour of 18-10-32 over Gala. The texture is firm, crisp and juicy and the flesh is resistant to oxidative browning. The fruit has very good storability and shelf life. The tree is very hardy.
18-17-11	Ripens near the end of September and hangs on the tree very well. It is very attractive having a smooth slightly flattened shape and having 100% red skin over a light green ground colour. The flavour has a sprite tartness to it with an excellent aromatic component. It has an excellent firm crisp and juicy texture and the storability and shelf life are excellent. The fruit is medium to large and the tree is very hardy.
18-22-23	Ripens near September 15. The skin is light green with a bright orange and yellow blush and there are numerous conspicuous lenticels making this a uniquely attractive apple. The flavour is rich with a tangy tartness and good aromatics. It has a very small closed core. The flesh colour is bright yellowish white and resistant to oxidative browning. The fruit size is medium to large and slightly flattened. The texture is firm, crisp and juicy and the storability and shelf-life are excellent. The tree is very hardy.

Apple Rootstock Selection

Dwarf rootstock is important in all regions that grow apples commercially. While warmer regions have upwards of 20 different varieties of dwarf apple rootstock to choose from, on the Prairies only Ott 3, Ott 8 and Bud 9 can be grudgingly recommended. None of these 3 varieties are wholly hard here. They seem to survive if the scion grafted onto them is very hardy. We have bred two of these varieties together (Ott 3 x Bud 9) in an attempt to obtain a more hardy dwarfing rootstock. Approximately, 250 seedlings were planted from this cross in the early 1990's. These seedling as well as other rootstocks from an Ontario program were observed during this grant.

We collected dormant scion wood in fall 2000 from our seedling for a grad student. They weren't needed and therefore, stayed in cold storage for an extended period. While discarding them in mid summer we noticed that some of them (listed below) had rooted. This indicates very good rooting potential.

Table 5.10. Promising apple rootstock selections that rooted in storage from hardwood cuttings.

7-1-11
7-1-16
7-1-19
7-1-22
7-1-24
7-1-31
7-1-33
7-1-40
7-1-43
7-1-44
7-1-45

Since scion wood was collected from less than half of the rootstock seedlings, others with good rooting potential will be found.

Apple rootstock selection October 2001

The winter of 2000/2001 severely affected the apple rootstock seedlings and approximately 50% were removed. A combination of a dry fall, little snow cover and a rapid temperature drop down to -30C in November contributed to losses. We are quite enthusiastic regarding the survivors since these plants had never had a severe test before. Since most of the seedlings are over a meter tall, the are especially susceptible to injury in winter as they are well above the snow line. Those trees without damage were propagated and grafted to test for dwarfing ability in 2002.

Ottawa #3

2000/2001 was very hard on Ottawa #3. Growers who received good stock and cared for it well, suffered significant losses. However, there is some suggestion that growers who suffered extremely heavy losses did not water well during and after transplanting last fall. Further work needs to be done in plant improvement and in grower education.

Ottawa #8
A few growers have expressed interest in planting Ottawa #8 because it is much hardier than Ottawa #3. Two hundred Ottawa #8 plants were distributed among three test sites where they can be compared with Ottawa #3. In particular the relative suckering habit, precocity and dwarfing effect will be noted.

V Series Apple Rootstocks
Of the seven rootstock clones in the V series, only three are now considered to be of commercial potential and worthy of further testing. They are V1, V2 and V3. V2 is reported to be less dwarfing than Ottawa #3 and, therefore, of marginal interest to us. Plants of V3 are thriving while plants of V1 are not doing well in the University of Saskatchewan stock nursery. Small numbers of V1 and V3 rootstock plants have been propagated and sent to co-operator sites for preliminary observation and comparison to Ottawa #3 under common scion cultivars. None of the V series clones has the anthocyanin gene with the accompanying visibility and convenience during propagation.

Seedling Rootstock Selection, April 2002

This winter with very little snow and fairly cold temperatures down to –35 C presented a stiff challenge to the Ottawa #3 X Budagovsky #9 seedlings that remain and probably damaged many of them. In any case we will be propagating the healthiest and hardiest of them this year and distributing them to grower test sites for evaluation. Those that propagate poorly will be dropped. The others will be evaluated for solid graft unions, precocity, dwarfing effect, yield efficiency, hardiness effect, tendency to sucker, and anchorage. Years from now the top selections could go into randomised and replicated trials with Ott 3 and Ott 8 as standards.

Ottawa #8 Clonal Rootstock
Since last winter caused much damage to newly-planted Ott 3, more growers are requesting Ott 8 for comparison to Ott 3. We will be propagating Ott 8 this year and offering it in small numbers to growers for testing. One of our co-operators is planning to propagate Ott 8 and offer it for sale to interested growers. Because of its excellent hardiness it is very attractive to growers in more northern zones.

V Series Clonal Apple Rootstocks
After this winter we should be able to make more interesting observations on the relative hardiness of V1 compared to V3, the two most promising dwarfing selections of the V series. Note: The V series rootstocks are from an old breeding program at the University of Guelph. Although breeding of rootstocks has ceased at Guelph, these rootstocks are undergoing PBR and may be propagated only though contracts with U. of G.

Table 5.11. Observation on winter injury on V series rootstock noted during spring and summer of 2002.

V1	April 2002: No damaged, tissue apparent but the stool plants are showing low vigour. June 6, 2002: There are some weak stool plants; Ottawa #3 is better.
V2	April 2002: The vigour of the stool plants seems good but slight xylem browning and some dead epidermis tissue is present. June 6, 2002: There are some weak stool plants; Ott 3 is better.
V3	April 2002: The vigour of the stool plants seems good but slight xylem browning and some dead epidermis tissue is present similar to Ott 3. June 6, 2002: There are some weak stool plants; Ott 3 is better. July 4: There are eight shoots broken by the wind compared to none on the other V selections and Ott 3. This suggests brittle wood.
V4	April 2002: The vigour of the stool plants seems ok but moderate xylem browning and a moderate amount of dead epidermis tissue is present.
V5	April 2002: The vigour of the stool plants seems ok but moderate xylem browning and a moderate amount of dead epidermis tissue is present. The shoots are very feathery.
V6	April 2002: Slightly worse than V4 and very feathery.
V7	April 2002: The vigour of the stool plants seems ok but moderate xylem browning and a moderate amount of dead epidermis tissue is present.
Note:	V4 through V7 are of little interest because they are reported to be less dwarfing than V1, V2 and V3.

Seedling Rootstock Selection, December 2002

Forty selections from among the apple rootstock seedling crosses (Ott 3 X Bud 9 and visa versa) were made this spring and cut down to the soil line to facilitate the propagation of juvenile tissue. Soft-wood cuttings were stuck in early July and plants (along with Ottawa #3 and Ottawa #8 as checks) were sent to test sites in August including some to John Lenart in the Yukon. John Lenart has research funding from government to pursue this work. Excellent rooting was seen on all selections. Researchers at Alberta Agriculture, CDC South, are very interested in testing these in Alberta including the Chinook regions. These selections will be propagated again in 2003 to complete collections at Saskatchewan test sites and to begin to supply test sites in Alberta.

We have very good reasons to believe that we will find at least several selections that will be superior to Ottawa #3 for use in the prairie region. Although we have no proof yet that they will be dwarfing, many of the selections are showing the same dwarfing phenotype exhibited by the parents, Ott 3 and Bud 9. All of the selections appear to be more winter hardy than their parents due to the genetic influence of hardy grandparents. All but two of the selections are like Bud 9 in that they have a noticeable level of anthocyanin pigment in the leaves and meristematic tissues. This will make them more efficient than Ottawa #3 for use in propagation and for maintenance of grafted trees.

Chapter 6. MISCELLANEOUS FRUITS

Pears

Pear seedling selections, April 2001

Two promising pear seedlings were found in the block 4 seedling orchard last fall. They are both half *Pyrus pyrifolia,* Asian Pear, with David pear as the hardy parent. One has excellent quality fruit of medium size on a semi-hardy tree. The tree is hardier than Ure. The fruit is about the same size but has an excellent shelf life like the Asian Pear. The other seedling has good-sized fruit of good quality but with a shorter shelf life. The hardiness appears to be about equal to Ure, although Ure hasn't fruited for us yet. Their seedling numbers are 4-1-47 and 4-2-50. We are planning to do crosses between the two this spring.

Pear rootstock, October 2001

We still maintain a long-term screening trial on pear rootstock selections. It will be at least several years before we can make meaningful observations on their suitability.

Pear seedlings, October 2001

Crosses were done between the two promising pear seedlings found in the block 4 seedling orchard last fall. Ure fruited for us this year and was decidedly inferior and had a very short shelf life compared to 4-1-47. By the time we harvested our hybridized pears the Ure pears had all rotted.

Pear Selection 4-1-47 (April 2002)

This selection has excellent fruit quality. It has the crisp texture of it paternal parent, an Asian Pear, but the rich sweet flavour of its mother (similar to a Bartlett Pear). Early evaluation suggests that it is likely good enough for commercial production anywhere it is hardy enough. It is an excellent keeper. We still don't know how long it can be held in storage (superior eating quality all the while). Since all the fruit in storage resulted from controlled crosses, we were forced to consume it in December to get the seeds, which we needed to stratify for germination this spring.

Those of us who work in the Domestic Fruit Program and other staff members all rate the fruit very highly. This pear is not hardy enough for commercial production in zone

2b. However, it will be tested to see if it is hardy enough for protected sites in cities and large towns and for commercial production on ideal sites in zone 3.

Pear Breeding (April 2002)

Controlled crosses were done among a number of seedling pear selections last spring, April 2001. The volunteer help of Mr. Dean Krutzer is gratefully acknowledged. Pear selection 4-1-47, which again showed excellent quality last fall, was crossed with two other selections, 4-1-46, which is a sister seedling with better fruit size and hardiness, and 4-1-43, which is another seedling with excellent hardiness and good fruit size. The entire tree of 4-1-47 was pollinated with 4-1-46 pollen.

We obtained 1032 seeds from these crosses and they are in stratification now awaiting germination later this spring. These pears are all genetically half *Pyrus pyrifolia*, quarter *Pyrus communis* and quarter *Pyrus ussuriensis*. Although they are not hardy enough for orchard production in zone 2b, some of their seedlings will be hardy commercial quality pears if they segregate as expected. Pear 4-1-47 is probably hardy enough to produce reliable fruit crops in protected locations (i.e. urban gardens) in zone 2b. After this has been shown to be true, it will be named and introduced. It inherited excellent texture and storability from *Pyrus pyrifolia*, excellent flavour from *Pyrus communis* and hardiness from *Pyrus ussuriensis*. Pears with similar interspecific combinations are at the cutting edge of pear breeding in China and other Asian countries where pears are more popular than apples.

Pear Breeding December, 2002

Pear crosses were made again this year. Four seedling selections, 4-1-43, 4-1-47, 4-1-49 and 4-3-1 were used as parents. The seeds were collected but put into storage because of the funding shortage. The pear seedlings in the shade house were not planted for the same reason.
The fruit of 4-1-47 was of excellent quality again this fall. This is a very promising selection for protected locations on the prairies. Its combination of keeping quality, texture and winter hardiness makes it outstanding among commercial pear cultivars in North America. It also has excellent sugar/acid balance and aromatic flavours. Several new trees of this selection have been started in block 19. New trees of 4-1-47 have been budded at test sites, also.

Plums

April 2001

Three trees each of Friar and Redheart have been ordered from Bylands Nurseries Ltd., BC, this spring. The plan is to use pollen from these trees on both *Prunus salicina* and *Prunus besseyi* this spring. Last spring we grafted some potted rootstock to Redheart and Elephant Heart plums. Pollen from these was used for breeding in spring 2000 on hardy *Prunus salicina* plums and eight seedlings resulted.

October 2001

The three trees each of Friar and Redheart and the grafted trees did not bloom so pollen was unavailable. These trees were potted and will be used next season if they bloom.

December, 2002

Plum crosses this spring yielded approximately 400 controlled-cross seeds of plums and sand cherries. Four *Prunus salicina* cultivars, Brookgold, Ivanovka, Ptitsin #3 and Ptitsin #5, and approximately fifteen *Prunus besseyi* seedling selections were used as hardy parents with *Prunus salicina*, 'Red Heart' as the high quality, pollen parent. The other high-quality California plums did not flower this spring. These are: Duarte, Black Amber, Friar and June Blood.

Sand Cherry (*Prunus besseyi*)

Germplasm collection

Bob Bors gathered 200 sand cherry seeds from four locations in western Ontario and eastern Manitoba in 1999. An additional 200 seeds of a yellow fruited mutant were obtained from Dwayne Barber of Swift Current, SK. This germplasm will be useful in developing new cherry plum cultivars. (Note: cherry plums are hybrids between sand cherries and plums) The mutant discovered by Dwayne Barber is particularly exciting because sand cherries and cherry plums are usually black, and black is dominant to other colours. This mutant may allow rapid development of yellow and red cherry plums.

In 2000 sandcherry seeds were gathered from the Honeywood Nursery Honeywood of Parkland, SK is a historic site which had a large collection of sandcherries and other fruits in the 60's and 70's. About 200 seedlings were established at the Hort Field Lab from this source.

Some of the sand cherry selections were used as hardy parents and crossed with Red Heart plum to create better quality new cherry x plum hybrids. The seedlings planted in 1999 bore heavy crops in 2002 and could be evaluated. Superior selections were identified including; red and yellow fruit colours and better flavours. It was noted that the best flavoured ones are mediocre at best and may benefit from introgression of plum varieties. Also identified were selections with ornamental potential: ones with bright red fall foliage and 'corkscrew' twisted branches. It was noted that the seedlings from Dwayne Barber were the most productive seedlings in the collection. The material from Honeywood has not yet fruited.

Raspberries

A raspberry plot that had been used for a trellis trial is in the process of being converted to evaluate a biennial bearing system. That system entails mowing rows every other year rather than pruning each year. The cultivars in the old trellis trial have not been evaluated under such a system. Several growers in the province do biennial mowing as a way to have increased acreage without the time consuming method of punning by hand. It will take a few years for the plot to convert into biennial production.

Cleanup via Tissue Culture, 2002:

Our raspberries varieties, SK Red Mammoth, and Red Bounty were put into tissue culture in order to have a verified clean source of plants. Last summer, these varieties were identified as having crown gall at the propagator's location. Investigations at the U of S found only two very small nodules on 2 out of 50 plants, which did not appear to have any *Agrobacterium* when cultured in the lab. It was decided at that time to develop and maintain stock cultures of our raspberry cultivars.

A few plants of SK Red Bounty and SK Red Mammoth, were removed from the field. After undergoing a vernalization period in our coolers at 2°C, the raspberries were brought into the greenhouse to initiate new shoot growth. When sufficient new growth was obtained, 2/3 of the growth was removed for tissue culture work.

The raspberry initiation media was prepared according to the recommendations of K. I. Ueno et al. The media includes: 23.21 g/l B5 Gamborg's medium, 1 mg/l benzylaminopurine (BAP), 3% sucrose, 0.3% Gellan Gum (Sigma Chemical, St. Louis, MO), with the pH adjusted to 5.8.
Twenty SK Red Bounty plantlets were placed in the media, while 70 SK Red Mammoth went into the same formulation.
After 1 month in the initiation media the plantlets were cultured onto a shoot proliferation media in which the hormone regime from the initiation media was altered. The proliferation media includes: 0.5 mg/l IBA and 0.5 mg/l BAP .
At present there are 12 Sk Red Bounty plantlets and 60 Sk Red Mammoth plantlets in the proliferation media. The plantlets are being monitored for their response to the media at present.

Samples of Red Bounty and SK Red Mammoth were send to Agdia Corp. in Indiana, USA for virus testing. Results showed them to be free of viruses. The tissue culture stock is being maintained as a source of 'virus-free' material.

Raspberry selection, SX00-12, continues to be very impressive with vigorous growth and very good quality fruit. We will continue to watch its winter hardiness. It seemed to suffer winter damage about the same as most of the other cultivars last winter. SK Steadfast was outstandingly winter hardy in 2001-2002.

Grapes

An observation trial was planted of 12 varieties of grapes in 2001. Most are expected to be hardy only to –30C so they will require additional winter protection. Seven varieties survived the first winter but no fruit was produced. Additional years of observation will be needed.

EXTENSION ACTIVITIES

Events

1999

New releases
Four new cultivars released in 1998 to propagators were sold to the public for the first time in 1999 (see pamphlet attached at the end of this document for descriptions). These varieties have been registered with COPF (Canadian Ornamental Plant Foundation) for the University to collect royalties. (note: there is no royalty collection agency for fruit crops in Canada, so COPF was chosen for this) The propagators with rights to propagate these varieties have sublicensed several other propagators, so it is expected that several nurseries will begin to sell our new cultivars in 2000. It is estimated that 8000 of each raspberry cultivars, 500 of SK Prairie Sun, and 4000 Carmine Jewel were sold primarily to nurseries, but some sales were made to growers and home owners. The low numbers sold of Prairie Sun are due to low supply of bud wood for grafting. Carmine Jewel is easily propagated by tissue culture and the two raspberries are rapidly propagated in the field.

Fruit Growers Annual Meeting
Samples of 40 apple selections and cultivars and 12 cherry selections were displayed at the annual meeting of the Saskatchewan Fruit Growers Association. Approximately 100 growers compared and sampled the fruit. Very favourable response was noted by growers. The growers identified selection **7-32-5.4** as being the best tasting cherry by a large margin. A talk was given on strawberry production by Bob Bors and on Cherry production by Rick Sawatzky. We were told that attendance at this meeting was much larger than previous years, and that this may have been due to interest in domestic fruits.

PFRA Field Day
Bob Bors gave a talk on 'Fruit for the Prairies'. This covered general practices as well as research at the U of S. New releases were promoted. Forrest Scarf and Heather Hack attended a display on our research and answered questions. They also handed out a pamphlet on our new cultivars.

Seagar Wheeler Farm, Pruning and Grafting Day
Rick Sawatzky gave a pruning and grafting demonstration for apples and cherries.

Seager Wheeler Farm, Seed Day
Bob Bors and Rick Sawatzky gave a pruning demonstration and discussed cultural practices for apples and cherries. This was done in a plot planted with our advanced selections.

Irrigation Crop Demonstration (at Metke farm near Swift Current)
Bob Bors gave guided tour through U. of S. selections of cherries, apples and cherry plums. About 250 growers attended.

Created display of apples and cherries from breeding program at Saskatchewan Fruit Growers Association=s annual meeting. Nov. 1999.

Created display for Domestic fruit Program at PFRA field day, July 1999.

Instructor at a pruning and grafting workshop@ at Seager Wheeler farm. July, 1999.

Manned Plant Sciences Booth at GardenScape Show, March 1999.

Presentation to visiting High School students for Experience Us event, Feb. 1999.

Manned Plant Sciences Booth at Crop Production Show, Jan. 1999.

2000

Organizational Activities

Bob Bors is the ex-officio U of S Board Member of the Saskatchewan Fruit Growers Association, representing the University of Saskatchewan. This position requires several meetings per year and assisting with planning of events and coordinating activities of SFGA. (Bors)

Board members of the Seager Wheeler Orchard Committee. The program planted, assists with maintenance, and helps to instruct employees of the Seager Wheeler farm in regard to their orchard care. (Bors and Sawatzky)

Test marketing, promotion and extension

Created display of strawberry species and tree fruit crops and answered questions at the Plant Sciences booth at GardenScape Show. April, 2000.

Attended Horticulture Industry workshop sponsored by Agri-food Innovation Fund. March 2000

Saskatchewan Fruit Growers field day:
Bob Bors set up a booth, which included a poster

Approximately 250 inquiries regarding fruit production or other horticultural activities were answered by Bob at the university. Such Inquiries were by phone, email, letter or in person. This number does not include questions answered at various field days and events.

Board member Seager Wheeler Orchard Committee.

Created display of strawberry species and tree fruit crops and answered questions at the departmental booth at GardenScape Show. April, 2000.

Attended Horticulture Industry workshop sponsored by Agri-food Innovation Fund. March 2000

Presentation to visiting High School students for Experience Us event, Feb. 2000.

Approximately 250 inquiries regarding fruit production or other horticultural activities were answered by me at the university. Such Inquiries were by phone, email, letter or in person. This number does not include questions answered at various field days and events.

Fruit Growers Annual Meeting
Samples of 40 apple selections and cultivars and 12 cherry selections were displayed at the annual meeting of the Saskatchewan Fruit Growers Association. Approximately 100 growers compared and sampled the fruit. Very favourable response was noted by growers. The growers identified selection **7-32-5.4** as being the best tasting cherry by a large margin. A talk was given on strawberry production by Bob Bors and on Cherry production by Rick Sawatzky. We were told that attendance at this meeting was much larger than previous years, and that this may have been due to interest in domestic fruits.

PFRA Field Day
Bob Bors gave a talk on Fruit for the Prairies. This covered general practices as well as research at the U of S. New releases were promoted. Forrest Scarf and Heather Hack attended a display on our research and answered questions. They also handed out a pamphlet on our new cultivars.

Seager Wheeler Farm, Pruning and Grafting Day
Bob Bors and Rick Sawatzky gave a pruning and grafting demonstration for apples and cherries.

Seagar Wheeler Farm, Seed Day

Bob Bors and Rick Sawatzky gave a pruning demonstration and discussed cultural practices for apples and cherries. This was done in a plot planted with our advanced selections.

Irrigation Crop Demonstration (at Metke farm near Swift Current)
Bob Bors gave guided tour through U. of S. selections of cherries, apples and cherry plums. About 250 growers attended.

2001

Organizational Activities

Ex-officio U of S Board Member of the Saskatchewan Fruit Growers Association, 1999-2000. This position requires several meetings per year and assisting with planning of events and coordination activities of SFGA. (Bors)

Board members of the Seager Wheeler Orchard Committee. The program planted, assists with maintenance, and helps to instruct employees of the Seager Wheeler farm in regard to their orchard care. A new plot of Raspberries were established that will demonstrate biennial mowing and alternate harvesting of raspberries. The Dwarf sour cherries began to produce at the Seager Wheeler farm, resulting in increased interest from farmers. We regularly advise and train their workers on orchard care. (Bors and Sawatzky)

Board member of GardenScape. This position involves planning of the largest garden show in western Canada. (Bors)

Grower Meetings

In cooperation with Craig and Yvette Hamilton, we organized and held an information seminar for new apple growers. The date for this was February 7, 2001 and approximately thirty growers attended. We presented the document entitled, "Grower Managed Apple Test Orchards, Administrative Guidelines for New Co-operators" (see Appendix). Also, two propagation workshops were scheduled for July 5 and July 31, 2001 at the Horticulture Field Lab.

We have received many inquiries from people who are starting apple orchards or planning to do so. Our suggestion has been that they buy rootstock and propagate their own trees. Interested growers were invited to one or both of the two Propagation Workshops which were held at the Horticulture Field Lab, 2909 14th Street, Saskatoon on July 5th and July 31st, 2001. About 40 people attended the first workshop and 60 the second workshop. A few growers attended both workshops.

Saskatchewan Greenhouse Growers Annual Meeting, October 2001
Bob Bors and Forrest Scharf set up and manned a booth describing our program. Apple varieties were on display and cherry jam was served. There was much

interaction with greenhouse growers who were interested in growing woody plants including fruit species.

Saskatchewan Fruit Growers Association Annual Meeting, Nov 2001

Bob Bors presented a talk on "Should You Grow Sour Cherries"

Rick Sawatzky and Forrest Scharf set up and manned a booth describing our program. Apple varieties were on display and Cherry Punch made from our Sour Cherries was served.

Grower Seminars
Two fruit growing workshops were organized by Bob Rugg and David Hryhor, SAF Saskatoon, and held at the Radisson Hotel in Saskatoon on Feb 8th and March 27th, 2001.
Bob Bors prepared Power Point Presentations and spoke on:

Strawberry Production*
Raspberry Production*
Dwarf Sour Cherry production*
New Fruit Crops for Saskatchewan: what might and might not work

(* Clarence Peters and Rick Sawatzky assisted with portions of these presentations)
Rick Sawatzky gave a slide show and spoke on:

Apple Testing at the University of Saskatchewan.

Each of the above talks was 1.5 hours long. Approximately 40 growers and the media were present at each event and CBC interviewed Bob (Feb 8) and Rick (Mar 27) and televised interviews that evening.

Displays
At both of the above workshops, Forrest Scharf set up an information booth and answered questions during breaks.

GardenScape
This year over 18,000 people attended the show. The theme of the University booth was 'Pruning and Training'. The display featured various trees and shrubs with half of the display being devoted to fruit crops including apples, cherries, raspberries and strawberries. Proper training and pruning methods as well as common mistakes were highlighted in a collection of 7 fruit trees. The display was created in such a way that it was self-explanatory and could be reused for other events. We anticipate using this display again during various fruit growing events in the coming year. The booth was very popular during the 3-day show, with people constantly approaching the booth and

asking questions. Either Bob Bors or Forrest Scharf were present during the entire show in addition to 7 student volunteers on various shifts.

The Domestic Fruit crew also prepared a joint display with the Seager Wheeler Farm for GardenScape 2001. (Note: Both Bob Bors and Rick Sawatzky are on the Seager Wheeler Orchard Committee). This booth had the theme "A Century of Innovation". Our crew created most of the display which included antique scrolls that had been used for teaching fruit and vegetable production in the1920's, scanned in reproductions of old varieties (from old books in the U of S collection) as well as antique tools and equipment. The Seager Wheeler crew manned the booth.

A data sheet entitled "**Dwarf Sour Cherry** , a two page guide" was written and submitted to the Prairie Fruit Journal. It was sent to individuals inquiring about our cherries, and propagators of SK Carmine Jewel. A copy of this info sheet is in the appendix of this report. This info sheet also serves the purpose of advertising the impending manual.

ABEX

One of our co-operators, Yoanna Nurseries and Orchards, owned by Craig and Yvette Hamilton of Radisson, SK, has been chosen an ABEX finalist in 2000 and again this year. This in itself is quite an achievement since four or five finalists in each category are chosen from hundreds of applicants each year. The award night is October 27, 2001. We are honoured to be a part of their success since the University developed the apple selections being grown by the Hamiltons.

2002

Grower Meetings

New Crops Workshop at U of S Bruno Campus, March 2002

Bob Bors presented a talk on "Fruit with potential: Mechanically harvested fruits".
The theme of this talk was to propose that Saskatoons, Dwarf Sour Cherries, Blue Honeysuckles and raspberries be grown together as they can all be mechanically harvested by the same equipment. These crops each have different fruiting seasons to spread operation activities throughout the season. This talk was largely based on an article I had written "Fruit with Potential", see appendix.

Crop Production Show, Jan 2002

Part of the Plant Sciences Booth had on display apples from our program, canned cherries, and canned blue honeysuckles. Bob Bors and Forrest Scharf helped man the booth. Frozen Cherries were given to Prairie Plant Systems (one of our co-operating propagators) where they served thawed fruit to the public. Keen interest was seen at the Plant Sciences Booth where many growers were surprised that Saskatchewan grown apples could be so large and that they could keep long enough in storage to be in a show in January. At the Prairie Plant Systems booth, they signed up 60 growers that were interested in purchasing cherry trees when they become available. For the most part these growers were ones that had not previously been associated with the fruit growers association nor with our cooperator program.

GardenScape, March 2002

The Plant Sciences booth had a plant propagation theme, and Bob Bors did bud grafting at the booth. (In actual fact, Bob was carrying out a grafting experiment for the program).

WEBSITE

In co-operation with Gloria Gingera of our Plant Sciences Department, we have been enhancing our website and have begun to post our fruit articles and photos on the web. This is incomplete, but already we have had many favourable comments from growers. See http://www.usask.ca/agriculture/plantsci/dom_fruit.

Saskatchewan Fruit Growers Association General Meeting, Oct 2002
Bob Bors gave the talk "Evaluating New Fruit varieties for potential markets"

Alberta Hort congress, Nov 2002
Bob Bors gave the following talks "Cold Hardy Sour Cherries" and "New fruit crops for the Prairie".
Rick Sawatzky assisted in setting up a display on apples and cherries.

Letters/email/phone calls
Bob and Rick are two of a small number of resource people who are available to growers that are starting domestic fruit orchards. Much time was spent communicating with co-operators and interested growers by group mailings and emails as well as by individual emails and phone calls. The time spent communicating on an individual basis can be estimated by considering that there are 148 growers that contact us twice each on an approximate annual average. Many growers visit us individually by appointment. Also, although we don't encourage it, some growers just drop in to ask questions or to see something. Usually, growers see how busy we are and are more considerate after that.

Field Days, Workshops and Conferences

April 30: Staff training and 'Planting, Planning and Pruning' field day at Seager Wheeler farm. Bob spoke on 'What's Hot', Clarence and Rick did a pruning demo and Rick did a grafting demo.

June 5: Seager Wheeler Farm field day called 'Seeding Trends'. We gave orchard tours and explain the Domestic Fruit Program work. Bob spoke on behalf of the College of Agriculture regarding the Agri-arm Network.

July 5 and August 2: Propagation Workshop at the Hort Field Lab. Details can be found in the document entitled, "Workshops 2002", which can be found in the appendix.

July 9: Field Day at Metkes. Rick Sawatzky and Forrest Scharf attended. Forrest spoke to groups about the strawberry diseases research and Rick spoke about the domestic fruit research and did a bud-grafting demonstration. This annual event is sponsored by Sask. Water (Sask. Provincial Government) and Treasure Valley Markets.

August 9: Bob attended the International Hort Congress in Toronto. The paper submitted appears in the apple section of this report.

August 15: Field day at Seager Wheeler Farm. Janine borrowed cherry catch tarp for harvest and for demonstration at Seager Wheeler Farm. Rick spoke on domestic fruit research and answered questions.

September 13: Rick gave a tour of the domestic fruit orchards for Bernie Nikolai from Alberta and Clare Lammers from Alaska and sent samples of apples with them to Edmonton for the Apple Tasting Days, which were held on September 14 and 15. Our apple selections, 18-10-32 and 18-22-23, were winners.

September 18: Apple tasting day at the Hort Plots. Our co-operators and interested growers were invited to attend and taste many of the apple samples that were in storage at that time. Also, Bob scheduled a student lab to taste apples on this occasion. Dr. Harvey Quamme, a research scientist and fruit breeder with Agriculture Canada for many years, attended to taste the apples and speak to the students. This provided us with more publicity than meaningful sensory data. However, it was clear that apple selection 18-10-32 was very well received and almost everyone found an apple that they really liked.

October 16 Talked about apples (with Clarence) and did apple tasting for Yorkton Hort Society in Yorkton.

Oct 18, Oct 21, Nov 5: Cherry seed planting days; Information about the cherry seed planting days was sent out in early October by mail and email. Twenty one grower operations were represented by one or two people each. Approximately 15,000 cherry seeds were planted. This event served both as a seed propagation workshop and cherry germplasm distribution.

November 14 and 15: Alberta Horticultural Congress in Edmonton. Bob gave two presentations - Bob-insert. Bob and Rick met with Thean Phen and Chris Nesser to plan co-operation with Alberta research. Both and Rick and Bob met with many interested growers one on one.

ARTICLES

The articles that follow were variously distributed either through the agrologist network, several were the basis of 'Farm and Food reports' , and/or have been used as handouts at talks or as mailings and given to the press. Most have been posted to the web.

Hardy Sour Cherries: choosing varieties, systems and markets

Dr. Bob Bors, Assistant Professor, Department of Plant Sciences, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5A8

Sour cherry varieties available in Canada vary tremendously for cold hardiness, tree form and fruit quality. There are three different types:

Prunus cerasus or "Sour Cherry"

True **sour cherries** are native to the areas around the Black and Caspian Seas. In an effort to make them sound more appealing, growers in the States have been calling them **tart cherries.** These cherries are often pruned to be 3 m tall but have the potential to be 15 m. Often they are grown on rootstocks that restrict their height from 5 to 8 m. Recently, the **Evan's Cherry** has been planted by many growers on the Canadian Prairie with mixed results regarding hardiness. Dieback can be severe in zone 2 and partial dieback is common in Zone 3. It may be possible to improve survival of Evans in colder areas with cultural practices that will be discussed later. The cultivars **Mesabi, Meteor**, and **Northstar** are recommended for Zone 4 in the southern half of Minnesota . Ontario is more conservative in its recommendation that sour cherries be planted in hardiness zones 5b or warmer. **Montmorency** is the most widely planted *P.cerasus* cultivar in the US and Canada providing 95% or more of the sour cherries on the market. Industrial cherry pitting machines, harvesting methods, and processing procedures have been developed for this cultivar, which may contribute to reluctance of sour cherry growers to switch to newer varieties. Harvesting of these cherries is usually done with trunk shaking equipment and large tarps that encircle the trees.

"Mongolian cherry"

In the late 40's, Dr. Les Kerr at Ag Canada's Morden Research Centre, began intercrossing ***P. cerasus*** and ***P. fruticosa.*** He continued this research when he moved to Saskatoon to become Director of the PFRA Tree Nursery (now Forestry Farm Park). What resulted was a cold hardy, bush sour cherry that grows 0.6 to 1.0m. (2 to 3 ft.) tall. Les began promoting these cherries to nurseryman and they began to be widely planted. These cherries are very sour, and most fruit are in the range of 2 to 2.5 gm in size or half the size of sour cherries. Their low form makes them difficult to pick. They are very hardy and can do well in Zone 2.

"Dwarf Sour Cherries" or University of Saskatchewan Cherries

In the 1970s, Dr. Nelson and Rick Sawatzky at the University of Saskatchewan imported and began evaluating *(P. cerasus* x *P. fruticosa)* hybrids from the Siberian Botanical Gardens. In the 1980's Les Kerr donated his germplasm to the University. A few years later hardy Mongolian cherries with unusually large size were hybridized to some of the best varieties from Europe. The hybrid cherries that were 75% *P. cerasus* and 25% *P. fruticosa* seemed to have a good balance of characteristics from both parents. Possessing both improved hardiness, and good fruit quality the hybrids are half the size of *P.cerasus*. At the U of S, nine year old, unpruned trees are between 1.5 and 2 meters in height. At this height dwarfing rootstocks are not needed so the trees can be on their own roots. It may be possible to use over-the-row harvesters that are more commonly used to harvest raspberries, blueberries, or saskatoons. The first cultivar released from the U of S was **SK Carmine Jewel.** Other advanced selections are being propagated for testing purposes.

Fruit Colour

Cherries are generally used according to their colour. Varieties, such as **Montmorency** and **Evan's Cherry**, are preferred for pies, preserves and toppings because of their bright red skin colour. However these varieties have yellow flesh and yellow or slightly pink juice. For this reason, most commercially produced cherry pie fillings are dyed red! The dark black cherries, such as **SK Carmine Jewel** and **Northstar**, have intensely coloured juice which is preferred for making juice, wine, jelly and adding to dairy products and baked goods. When dark cherries are used in a pie, the fruit looks a darker than what you'd buy in the store. Some European varieties being tested in Michigan as well as some U of S selections have red skin and red flesh would be a good alternative for making pies without dyes. Cherries having yellow flesh are particularly prone to oxidation, and will turn brown if not cooled and processed shortly after picking. Cooking or freezing whole or pitted cherries will release pigment from the skin of the fruit, so it is possible to obtain red juice from Evans and Montmorency.

Pit Shape and pitting

Round pits such as those in **SK Carmine Jewel, Northstar,** and **Montmorency** are best for motorized pitting machines. Long pits like those in **Evans** and **Meteor** are less desirable because they may shatter. The hand operated pitters used by homeowners are acceptable for all varieties because they do not have enough force to break pits. Plunger type pitters take more time for homeowners to pit their cherries but are inexpensive ($15-20). The old fashioned crank type are 7x faster, but the fruit comes out flat and pitters may cost $70 to150. Commercial pitting machines may cost $5000 to 30,000 US depending if you buy it used or new. They can process up to a ton per hour.

Sweetness

Surprisingly, sour cherries can have as much or more sugar than sweet cherries. Some wine recipes require less sour cherries per batch than sweet cherries. Very late in the season, some varieties of sour cherries lose most of their acidity and astringency and can be eaten fresh. The tartness doesn't completely go away, but taste tests indicate that most people enjoy the fresh taste of Evans and SK Carmine Jewel late in the season. Children, in particular enjoy them, perhaps preconditioned by the variety of sour candies on the market. Also, sour cherries are much more juicy and smaller than sweet cherries. Sour cherries taste best when they can be shaken off the trees.

Suggestions for improving hardiness

0. Plant in a protected area with well drained soil. Avoid low lying areas where cold air collects. Windbreak are recommended for North and West sides of the orchard.
1. Never do general pruning in summer or fall, it would encourage late growth and increase chances of winter damage; late winter or early spring is the best time. Pruning of damaged branches can be done at anytime.
2. Don't remove more than 25% of the wood in any one year. To remove more wood may encourage vegetative growth and reduce fruit yield the following year.
3. Use fertilizer only if necessary and apply only in the spring.
4. Reduce or stop watering in the fall, this helps to make the trees go dormant. Exception: a drought year with young plants.
5. To encourage growth of young trees the area around trees can be cultivated to remove competition of weeds and grass. Later in summer, allow grass to grow into the row, as the competition will hasten the onset in dormancy. Full size trees can have grass growing close to the tree all season long, encouraging deep root growth.

Pollination

Sour cherries of all types are usually self-fruitful and do not require other varieties for pollination. However, bees are needed to transfer pollen from the anthers to the styles. Wild bees may play an important role if bloom time occurs when it is too cool for honeybees. It might be possible that having several varieties will increase fruit set. Although self-fruitful, sour cherries are notorious for having fruit set in the 20 to 30% range, so actions taken that could potentially increase fruit set should be explored.

Pests and diseases

The most serious pest for the prairies has been has been deer and rabbits eating branches in the winter. They will also eat fruit an leaves in summer. Deer fences are highly recommended. At the University's research plots we had cherry fruit fly *(Rhagoletic cingulata)* and leaf rollers which we spray 2 or 3 times a year. We have not seen any bacterial leaf spot on our cherries, which in Michigan is a very serious disease. It is not known if Saskatchewan cherries have immunity for this disease or if Saskatchewan is climate is too unfavourable for it to become a problem.

Harvesting

The U. of S. cherries have been bred for mechanical harvesting and could be harvested with an over the row harvester. They can also be shaken by hand. The average size cherry bush can be harvested in about 3 minutes by this later method. Likewise, Mongolian cherries can also be mechanically harvested. Pruning must be done to restrict the width of the bushes so branches can fit into the opening of the harvester.

The large tree type of sour cherry such as Evans or Montmorency require specialized hydraulic shaking equipment, which is considerably more expensive than an over-the- row harvester. The branches of these tall trees are too thick for shaking by hand and so ladders and hand picking would be the only other harvesting option.

Market potential

The cherry pie filling market is dominated by the Michigan growers but other cherry products are rare on the market. A natural pie filling without dyes could have potential in the market. Cherry juice, wine, dried cherries, cherry muffins are almost non-existent. Frozen cherries cannot be bought in the prairie provinces at any time of the year but in Ontario they are available only during harvest season. Cherries with yellow flesh, such as Montmorency or Evans, easily oxidize when thawed and become muddy brown in colour. The darker cherries such as SK Carmine Jewel, become purple after thawing.

For some of these products the cranberry would be the biggest competition, but I would venture to guess that cherries are more liked by the public. Some growers in the States have switched to a red juiced cherry and are selling concentrated cherry juice for its medicinal properties. As the U of S cherries are very dark red to black with highly coloured juice, it is likely that they will be used in products other than pies, but would be superior for other products.

Future Research

Advanced selections with good fruit quality are being propagated for testing purposes. Although hardy in Saskatoon (Zone 2b) some selection have had limited testing in zones 2 and 3, while other selections have not been tested. I am interested in co-operating with government researchers and grower groups across Canada. I believe that the Dwarf Sour Cherries have the much potential to be a new crop for northern regions.

Opportunities for fruit production In Saskatchewan

by Dr. Bob Bors, Plant Sciences Department, U. of S.

Introduction

It may be surprising to some that fruit breeding and research has been ongoing at the University of Saskatchewan since the early 1920's. Fruit breeding takes a least a decade between generations , so improvement in both hardiness and fruit quality have taken a while to achieve. For some crops, notably apples and sour cherries, the quality of some of the new varieties equals or surpasses what is commonly found in grocery stores. These achievements as well as research done on producing native fruits have greatly reduced the risks a fruit farmer needs to take. With any crop there is always a risk. I get alarmed when someone asks "What crop should I grow?" To grow only one crop is rather risky. A better question would be "What crops would be good to grow together?" Having a diversity of crops helps to make every year a good year. 2000 was a good year for strawberries and cherries, but a disaster for saskatoons. 2001 was a disaster for strawberries, good for cherries, but a bumper crop for saskatoons. Diversity also spreads the cost of equipment, labour and facilities.

Fruit farms that have diversified are mainly pick-your-own farms or take produce to market. There are also a number of farms which specialize in native fruits which have wide appeal locally and make interesting products for niche markets internationally. In this article I want to discuss two other options with potential: fruit that can be mechanically harvested or those that can be produced organically. I have also included a couple charts on the crops of which I am most familiar in which I have highlighted some of the main points to consider when planning a fruit farm.

Mechanically harvested crops

Harvesting a fruit crop is easily one third or more of the cost of production. Depending upon the weather, harvest season can be very short, drawn out, early or late. This does not make it easy to plan for a workforce to harvest a crop. It is even more difficult to raise a labour force when Saskatchewan has a low population base, laws are unfavourable for importing foreign labour, most young people would rather have a steady job, and most farms are far from the cities. Even if foreign labour is allowed, it will be difficult to attract workers, since our growing season is much shorter than other places in North America. A creative solution would be to have many different crops or some other business that could employ workers over a longer period. Perhaps an organic farm would be a more desirable place to work and might have an easier time attracting employees.

Mechanically harvested crops that would fit well together are blue honeysuckles, saskatoons, dwarf sour cherries, and raspberries. These four crops could be harvested with the same over-the-row harvester. And could utilize the some of the same cleaning and cooling equipment. Except for some overlap between the cherries and raspberries, the above crops have different harvest times, which would be especially good for producing a series of products. They can be used in similar products, such as jams, pies, and toppings. Pruning for blue honeysuckles, saskatoons, and dwarf sour cherries would be very similar and easier to teach employees. I did not include seabuckthorn in the above list because it is uncertain if it can be mechanically harvested. Specialized equipment is being developed that could make all the difference in the feasibility of this crop. As seabuckthorn is very difficult to pick, it might be possible that a seabuckthorn harvester will be able to harvest other crops too. Also, breeders at PFRA are attempting to breed easier to harvest varieties.

Organic Production

The cold winters and dry, hot summers have the advantage of keeping down insects and pests. Fruit farms in the Okanagan valley or Niagara region are close together which facilitates the spread of pests. But in Saskatchewan, fruit farms are separated by many miles. Also, we can't grow most varieties from other regions we probably don't import as many pests with our tree fruits. (But we regularly import pests in strawberry and raspberry plants). Wild stands of native crops such as saskatoons and chokecherries can be a constant source of pests, especially to native crops. When crops not native to our area are planted, it is less likely that native pest will attack them, so these crops that have the greatest potential for organic production.

It is extremely difficult to produce organic fruit in the major fruit producing regions. Consequently, there is a great shortage of organic produce and conversely a large demand. Most fruit producing areas in North America spray their crops every 7 to 10 days. To skip spraying once, often means the crop will suffer heavy damage and may become a loss. (Incidentally, while saskatoon growers may complain about the amount of spraying they do, they are in fact spraying far less growers in other regions). At the U of Sk. We spray 2 or 3 times years for many crops and hardly have any fruit loss. This is quite remarkable considering we have been growing fruit for 80 years at that location and that we are located in the city. City dweller often don't spray so pests could build up, if it weren't for our winters. I would venture to guess that an organic producer could get 50% more either wholesale or retail levels for his produce. Contrary to popular belief, costs for organic production is often higher than conventional farming (hand weeding, organic fertilizers, organic pesticides). It takes sharp, observant individuals to be successful organic producers. Often growers encounter pests for which there is no ready-made organic solution and the grower must experiment on his own to find a solution. One should keep in mind that the longer one is in production the more likely that pests can build up in an orchard.

For organic production I recommend apples, dwarf sour cherries, blue honeysuckles, and seabuckthorn. These crops have few insects or disease problems in Saskatchewan. The apples and cherries have a wide appeal in the marketplace while honeysuckles and seabuckthorn are virtually unknown.

Market Potential

Much of market potential has to do with price and quality. Land is much cheaper in Saskatchewan than major fruit producing regions. Prices of $10 to 15K/acre are

Table 6.1. Comparison of key attributes of a few fruit crops.

Crop	Marketing Advantages	Marketing Disadvantages
Blue Honeysuckle	1st fruit in season, ripens before strawberries! Multi-use Similar colour to saskatoons and blueberries Juice is deep red/purple	Virtually unknown in North America Unusual shape fruit, unlike any other berries, (Reminds me of an butterfly pupae) Short harvest window Soft fruit, more difficult for fresh market
Strawberry	Early fruit Familiar crop to North Americans Local produce has better taste	California competition Soft fruit, more difficult for fresh market Bending over to pick them
Saskatoons	Well known locally Several Sk manufacturers producing products Looks like a blueberry Niche markets	Virtually unknown outside of Prairies Soft fruit, more difficult for fresh market
Dwarf Sour Cherries	Familiar crop to North Americans U of Sk varieties have much better quality than the standard 'Montmorency'. Highly coloured juice Neutraceutical potential	Deer love it, deer fences usually needed Pit removal needed for many products Soft fruit, more difficult for fresh market
Raspberries	Familiar crop to North Americans, Multiuse	Very soft fruit, more difficult for fresh market, has thorns
Apples	Rare to see organic apples in the market Familiar crop to North Americans Can be stored fresh for many months Consumers are trying new varieties Apples are often combined with other fruits in juices and fruit leather	Oversupply of apples international
Seabuckthorn	neutraceutical potential, high in vitamins juice potential, cosmetic uses	Virtually unknown in North America

pies, and toppings. Pruning for blue honeysuckles, saskatoons, and dwarf sour cherries would be very similar and easier to teach employees. I did not include seabuckthorn in the above list because it is uncertain if it can be mechanically harvested. Specialized equipment is being developed that could make all the difference in the feasibility of this crop. As seabuckthorn is very difficult to pick, it might be possible that a seabuckthorn harvester will be able to harvest other crops too. Also, breeders at PFRA are attempting to breed easier to harvest varieties.

Organic Production

The cold winters and dry, hot summers have the advantage of keeping down insects and pests. Fruit farms in the Okanagan valley or Niagara region are close together which facilitates the spread of pests. But in Saskatchewan, fruit farms are separated by many miles. Also, we can't grow most varieties from other regions we probably don't import as many pests with our tree fruits. (But we regularly import pests in strawberry and raspberry plants). Wild stands of native crops such as saskatoons and chokecherries can be a constant source of pests, especially to native crops. When crops not native to our area are planted, it is less likely that native pest will attack them, so these crops that have the greatest potential for organic production.

It is extremely difficult to produce organic fruit in the major fruit producing regions. Consequently, there is a great shortage of organic produce and conversely a large demand. Most fruit producing areas in North America spray their crops every 7 to 10 days. To skip spraying once, often means the crop will suffer heavy damage and may become a loss. (Incidentally, while saskatoon growers may complain about the amount of spraying they do, they are in fact spraying far less growers in other regions). At the U of Sk. We spray 2 or 3 times years for many crops and hardly have any fruit loss. This is quite remarkable considering we have been growing fruit for 80 years at that location and that we are located in the city. City dweller often don't spray so pests could build up, if it weren't for our winters. I would venture to guess that an organic producer could get 50% more either wholesale or retail levels for his produce. Contrary to popular belief, costs for organic production is often higher than conventional farming (hand weeding, organic fertilizers, organic pesticides). It takes sharp, observant individuals to be successful organic producers. Often growers encounter pests for which there is no ready-made organic solution and the grower must experiment on his own to find a solution. One should keep in mind that the longer one is in production the more likely that pests can build up in an orchard.

For organic production I recommend apples, dwarf sour cherries, blue honeysuckles, and seabuckthorn. These crops have few insects or disease problems in Saskatchewan. The apples and cherries have a wide appeal in the marketplace while honeysuckles and seabuckthorn are virtually unknown.

Market Potential

Much of market potential has to do with price and quality. Land is much cheaper in Saskatchewan than major fruit producing regions. Prices of $10 to 15K/acre are

Table 6.1. Comparison of key attributes of a few fruit crops.

Crop	Marketing Advantages	Marketing Disadvantages
Blue Honeysuckle	1st fruit in season, ripens before strawberries! Multi-use Similar colour to saskatoons and blueberries Juice is deep red/purple	Virtually unknown in North America Unusual shape fruit, unlike any other berries, (Reminds me of an butterfly pupae) Short harvest window Soft fruit, more difficult for fresh market
Strawberry	Early fruit Familiar crop to North Americans Local produce has better taste	California competition Soft fruit, more difficult for fresh market Bending over to pick them
Saskatoons	Well known locally Several Sk manufacturers producing products Looks like a blueberry Niche markets	Virtually unknown outside of Prairies Soft fruit, more difficult for fresh market
Dwarf Sour Cherries	Familiar crop to North Americans U of Sk varieties have much better quality than the standard 'Montmorency'. Highly coloured juice Neutraceutical potential	Deer love it, deer fences usually needed Pit removal needed for many products Soft fruit, more difficult for fresh market
Raspberries	Familiar crop to North Americans, Multiuse	Very soft fruit, more difficult for fresh market, has thorns
Apples	Rare to see organic apples in the market Familiar crop to North Americans Can be stored fresh for many months Consumers are trying new varieties Apples are often combined with other fruits in juices and fruit leather	Oversupply of apples international
Seabuckthorn	neutraceutical potential, high in vitamins juice potential, cosmetic uses	Virtually unknown in North America

Table 1. Comparison of key attributes of a few fruit crops, continued

Crop	Harvest Time in SK	winter hardiness	Frost on flowers	Organic potential	Mechanical Harvesting
Blue Honeysuckle	mid to late June	Very Hardy	Possible	very possible	yes
Strawberries	early July	depends on year	Possible	difficult	no
Saskatoons	July	Very Hardy	Possible	difficult	yes
Dwarf Sour Cherries	late July - early Sept.	depends on variety	Possible	possible	yes
Raspberries	early Aug (summer bearers) or early fall	depends on variety	unlikely	maybe	yes
Apples	Sept - Oct	depends on variety	Possible	possible	no
Seabuckthorn	Sept	Very Hardy	unlikely	very possible	under development

Acknowledgement:
Saskatchewan Agriculture and Food provides operating funds for fruit breeding and research at the University of Saskatchewan.

GROWER MANAGED APPLE TEST ORCHARDS
Administrative Guidelines for New Co-operators
February 20, 2002

Introduction

This information is for growers who want to test the University's apple selections on their own property in cooperation with the Plant Sciences Department, U of S.

The purpose of this program is to obtain information on yield and fruit quality. Participants in this project will be expected to fill out questionnaires for 3 production years. It is believed that this data will be very useful to growers, researchers, government granting agencies (research money), and bankers (loans and insurance for growers).

There are only 40 apple selections on the advanced test list this year and all of them have potential for commercial production on the prairies. All of them have characteristic(s) which make them outstanding for different uses at different ripening dates. They represent a range of textures, flavours and colours which will accommodate the public's different preferences. They all represent a potentially large improvement in hardiness and/or quality over all of the named cultivars presently recommended to prairie growers. Six of them should compete well in flavour and texture characteristics with the world's best and these six have been listed and described in a separate document entitled, "Most Promising Apples 2002".

Each year we plan to show fruit from our advanced apple selections at the Saskatchewan Fruit Growers annual meeting and convention.

We are inviting you to help us find the best and most reliable apple selections over time. There are both benefits and inconveniences involved in co-operating with us in this testing. These are outlined below. You may decide to use our advanced selections for commercial production only and not be a test co-operator.

Propagation Workshops

We are suggesting growers buy Ottawa 3 dwarfing apple rootstock and bud their own trees to our advanced selections. The rootstock should be planted in the orchard at orchard spacing (see below) and budded in place (i.e. not transplanted). **Propagation workshops** will be held at the Horticulture Field Lab, 2909 14th St. (Horticulture sign on the fence), Saskatoon on **Friday, July 5th and Friday, August 2nd 2002.** The agenda, identical on both dates, will be sent out by mail. The workshops will focus on the bud-grafting technique used in starting new apple trees.

Choices

Growers are required to sign a Non-Propagation and Ownership Agreement with the University to grow our apple selections whether or not they are a test co-operator. Budwood for the yield and quality testing will be provided free of charge for five trees of each selection, but if growers want budwood for more trees or if they decide not to be a test co-operator, there will be a $.30 handling and administration fee per bud.

To qualify as a co-operator, a grower will need to plant 5 trees each of at least 5 selections of our choice and a standard cultivar equalling 30 trees in one location. We would like these trees tested by growers contemplating having a commercial sized orchard. (What's commercial size? 100 trees is really small; 550 might be good for a local 'pick-your-own' operation; wholesalers in the east have tens of thousands of trees). A grower may obtain budwood for 5 trees each of as many as 40 test selections plus budwood from a few established named cultivars and receive this at no charge. SK Prairie Sun will be one of these standard trees.

There are alternatives to budding your own trees. If a grower can't or does not wish to bud their own trees, there are three options. **Firstly**, a grower can hire a propagator (for names contact Rick or Bob) to do the budding in the growers new orchard as though the grower were doing it. **Secondly**, the grower can contract a wholesale propagator to grow the trees and ship them to the orchard site. **Thirdly**, a grower will be able to buy equal numbers of trees of five advanced selections from a wholesale propagator. If any of these options is chosen, fees would apply to non-test trees as usual. The grower is responsible for wages or contract costs.

Ottawa 3

For sources of Ottawa 3 see the Suppliers List. This dwarfing rootstock is very close to being fully recommended for prairie zones 2b and warmer. It isn't perfect but we know its weaknesses and can suggest appropriate cultural practices (wiz. Be careful not to over fertilize the first year. Under some conditions plants will need protection for the first winter. Keep the bud unions at or below 5 cms from the soil line).

The use of Ott 3 will allow tree densities of between 545 to 726 trees per acre (1347 to 1793 trees per hectare) depending on row spacing and will facilitate the most convenient cultural practices. This is based on 5 ft. (1.5 m) between trees and from 12 to 16 ft. (3.7 to 4.9 m)between rows.

Growers in zone 2a who don't want to take the risk on Ott 3 are advised to buy crab-apple seedling rootstocks and plant at 12 by 16 ft. (3.7 by 4.9 m) which will be 227 trees per acre (560 trees per hectare). Ottawa 8 is not as dwarfing as Ott 3 but is much hardier and, plans are being made to test it in zone 2a. It is looking promising at the University site. We have a small quantity of Ottawa 8 rootstock available for anyone in zone 2a who is interested.

Fee Structure

Budwood fees apply to non-test trees and are based on the number of established trees. Therefore, buds that fail to 'take' will be replaced at no charge. Budwood is available in August.

Budwood fees for **SK Prairie Sun** include a 15 cent cutting and handling fee and a 40 cent royalty plus shipping charges (i.e. **55 cents plus shipping**).

Budwood fees for any of the **advanced selections** include 15 cents for cutting and handling and 15 cents for records and administration plus shipping. (i.e. **30 cents plus**

shipping) This is the same fee that BC researchers charge growers for propagating their advanced selections.

There will be 40 cents royalty per tree included in the price of all apple trees purchased from wholesale propagators. (The royalty for cherries is 20 cents per tree.)

Procedure

1. Sign and mail the agreement form to: Plant Sciences Department, 51 Campus Drive, Saskatoon SK S7N 5A8, att. Rick Sawatzky
2. Order rootstock if you have not already done so.
3. Please notify Rick or Bob regarding how many trees you will be planting and when. and which workshop you plan to attend.

Notes

1. Rootstock planted in fall will be ready to bud in August of the next year.
2. Rootstock planted in spring will be ready to bud in August of the same year.
3. Start small and increase orchard size as you become familiar with the crop and develop a customer base.
4. We do not know how large an apple industry can be supported in Saskatchewan.
5. The world market for non-organic apples is over supplied at the present time and other producing areas have a marketing and distribution advantage for this product. Some countries are dumping apple products on the market.
6. We have production advantages such as lower land costs and fewer pests and diseases in Saskatchewan.

Feel free to contact Bob or Rick with any questions that you might have.

Dr. R. H. (Bob) Bors, Ph.D.
Assistant Professor, Plant Breeder
Department of Plant Sciences
51 Campus Drive
Saskatoon SK S7N 5A8
phone 306 966 8583
fax 306 966 5015
email: bob.bors@usask.ca

J. R. (Rick) Sawatzky
Technician IV, Plant Breeder
Department of Plant Sciences
51 Campus Drive
Saskatoon SK S7N 5A8
phone 306 978 8316 or 966 5858
fax 306 978 8643
email: rsawatzky@sk.sympatico.ca

Domestic Fruit Program web site: http://www.usask.ca/agriculture/plantsci/dom_fruit/index.html

TESTING APPLES

Pros and Cons

The benefits of being a test co-operator are:

1. Having many varieties with different ripening dates will extend your harvest and be more convenient for you and your customers.
2. You can better meet the public's wide range of flavour and texture preferences and you may attract more customers because of this.
3. A mixture of apple genotypes results in excellent pollination.
4. You will gain first hand knowledge of which selections do best under your conditions and which selections are most popular in your area. You can use this information when planning an expansion.
5. Notes and yield data in particular may be of benefit for obtaining crop insurance and bank loans and in organising coops and distribution networks for the produce.

The inconveniences are:

1. There is more work in maintaining the identity of small batches of test trees and keeping notes on their performance (winter hardiness, ripening date, rough yield, and fruit quality comments).
2. Many of the selections will require different cultural techniques. For example, some will require heavier pruning and fruit thinning.
3. Some selections will turn out to be second or third best in their category and ripening date. You will likely want to top-work these after the testing is done.
4. The University may ask for a small test sample on occasion.

Dwarf Sour Cherry -

a two page guide

Dr. Bob Bors, Assistant Professor, Department of Plant Sciences, University of Saskatchewan

The University of Saskatchewan released the first dwarf sour cherry cultivar, 'SK Carmine Jewel' in 1999. 'SK Carmine Jewel' was selected because of its dwarf stature (2m) trees of excellent hardiness, which produce early-ripening, dark red fruit high in sugar and easy to harvest by shaking from the tree. The U of S expects to name and release other superior seedlings in the near future.

The dwarf sour cherry combines the small stature and excellent hardiness of Mongolian cherry *(Prunus fruticosa)* with the fruiting characteristics of sour cherry *(P. cerasus)* to produce small trees with fruit that looks and tastes like better known sour cherries cultivars such as 'Evans', 'Rose', and 'Montmorency'.

Manual: A manual dealing with production of dwarf sour cherries is presently being produced. It is slated for release in 2002.

Hardiness: Dwarf sour cherries were bred in zone 2b to survive winter lows of -40°C without damage. While 'SK Carmine Jewel' has proven hardy in Saskatoon and several other Saskatchewan locations, the dwarf sour cherry is still in the experimental stage. Growers are advised to begin at a small scale and expand to larger operations as more becomes known.

Spacing: Within-row spacing for mechanical (over-the-row harvesters) is recommended at 1m while spacing of 1.5m are recommended for hand-harvested or shaken trees. Between row spacing of 5m or more should be determined by tractor width. Where larger implements are not being employed between-row spacing can be substantially narrower.

Fertiliser: Many prairie soils have adequate soil fertility to sustain dwarf sour cherries. Soil testing and fertiliser incorporation prior to planting is recommended. Subsequent fertilising should take place only during spring as rapid succulent growth later in the growing season is prone to winter injury.

Watering: During the first three years watering is extremely important to tree establishment. Irrigation is less critical for established trees. The established orchard at the U of S is seldom irrigated. The underlying heavy clay soil retains enough moisture to satisfy the trees= demand. Where irrigation is provided, it should be discontinued in fall to encourage dormancy development.

Grass Cover: Grass between rows serves to reduce mud, and to complete with trees for moisture at the end of the growing season. In dry areas it is best to maintain grass-free alleys between rows. Similarly, establishing trees should be kept grass and weed free. In areas with adequate moisture, grass can be permitted to fill in below established trees. Some growers keep orchards weed/grass free through July, but permit weeds and grass to grow in August to reduce the available moisture supply promoting dormancy, and also facilitates snow trap. Long grass in winter may however also provide winter cover for rodents that gnaw bark and girdle trees.

Windbreaks: Protection to the west and north of any prairie orchard is highly recommended. Winter damage is often a function of desiccation caused by direct exposure to prevailing winds.

Harvest: Trees begin bearing three years after planting with respectable crops after five years and peak capacity reached after seven. In Saskatoon 'SK Carmine Jewel' is harvested in late July and early August. The fruit holds well for at least three weeks after ripening. Future cultivars slated for release should extend the harvest season to early September.

Yield: Yield data collection is still in preliminary stages. However preliminary estimates fall in the range of 10 to 15Kg per fully mature tree.

Pests: Deer browse winter twigs as well as leaves and fruit so deer fencing is recommended. At the U of S we spray two to three times per season in MAY and JUNE for cherry fruit fly. Very few other pests are observed. The trees show excellent resistance to black knot, but a few cases of bacterial canker have been noted.

Pruning: More research is needed to determine optimum pruning techniques for dwarf sour cherries. Until more is known, trees may be pruned to an open centre vase, like plums, or as a renewable shrub like saskatoons. Pruning should be undertaken in winter or early spring.

Uses and Fruit Quality: The fruit of 'SK Carmine Jewel' is red by mid-July, but will become almost black by early August. Because it has bright red juice and high sugar content, it is excellent for juice, wine, or any product where development of a 'cherry pink' colour is desired.

Cherry pies in North America are traditionally made with 'Montmorency' cherries, which have red skin, yellow flesh and pale pink juice. Fillings made with these cherries are typically dyed to enhance the expected 'cherry red' colour. Consumers used to an artificial 'cherry red' may perceive pies made with 'SK Carmine Jewel' as too dark. You may need to educate consumers that your products are made without artificial dyes.

Motorised cherry pitting machines are difficult to find and expensive. You may wish to buy smaller hand-operated pitting machines and sell them to consumers.

Stains: Dwarf sour cherries do not stain countertops or clothing like other fruits. Countertops usually wipe clean, and stains wash out of clothing with a simple cold water wash.

Market: Cherries are well loved by the public. At a recent horticulture show 50% of people sampling the fruit commented they would eat them fresh with no processing. Pick-your-own cherries are good for customer flow because they follow saskatoons but precede apples.

Contacts: Many nurseries are currently propagating this cultivar with the primary propagator being Dn'A Gardens, Box 544, Elnora, Alberta (403) 773-2489. People who are new to fruit growing may consider joining one of the provincial associations: Saskatchewan call Charon Blakley (306) 645-4447, Manitoba call Waldo Thiessen (204) 328 8083, Alberta call Nadine Stielow (780) 998 0481. These groups hold conferences, tours and workshops, with members also receiving a subscription to the *Prairie Fruit Journal.*

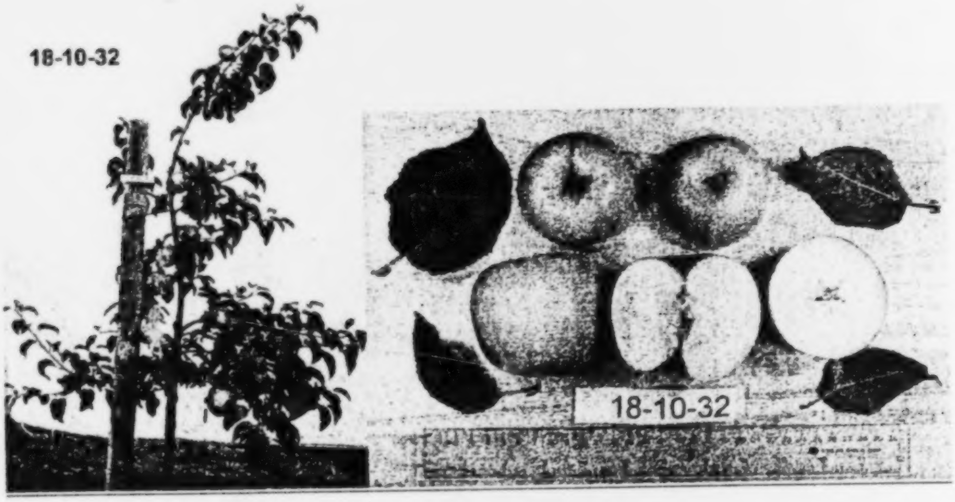
Pollination:

Dwarf Sour Cherries are self-pollinating so only one variety is required. Bees help improve fruit set by moving pollen from anthers to the styles.

Acknowledgements: Saskatchewan Agriculture and Food and the University of Saskatchewan financed the breeding and research of dwarf sour cherries. Dr. Les Kerr, Dr. Cecil Stushnoff and Rick Sawatzky made significant contributions over the 50 years of development. Dr. Bob Bors, Rick Sawatzky and Forrest Scharf are currently involved in fruit breeding at the U of S.

DESCRIPTION OF 18-10-32 APPLE

Figure 6.1. Young tree and fruit of 18-10-32



Description

Ten fruits were evaluated.

The maximum fruit diameter is 8.6 cms. while the minimum is 7.3 cms. The average is 7.63 cms which is very close to 3 inches.

The fruit is born singly on spurs and tends to self-thin. The tree is hardy, open and slightly leggy, intermediate between a spur-type and a tip-bearer.

The ripening date is near mid September in Saskatoon.

The fruit form is roundish but slightly oblate while the cross-section is round and the longitudinal section is slightly unequal.

The skin colour is approximately 50% orange/red wash and stripe over a light green ground colour with scant bloom and numerous, inconspicuous dots (lenticels).

The skin is smooth and medium thick.

The calyx is persistent and convergent/recurved. The calyx tube is closed and conical. The basin is wide with basal stamens.

The stem is short and medium thick. The cavity is acute.

The flesh colour is white.

The core is closed and small to medium in size with a median position. The core lines are slightly clasping. The carpals are slightly emarginated.

The seeds are medium brown and acute.

The flesh texture is fine, firm, tender, crisp and juicy.

The flavour is sweet and slightly sub-acid with a very pleasing aromatic component.

The fruit quality is very good and the storability and shelf-life are very good.

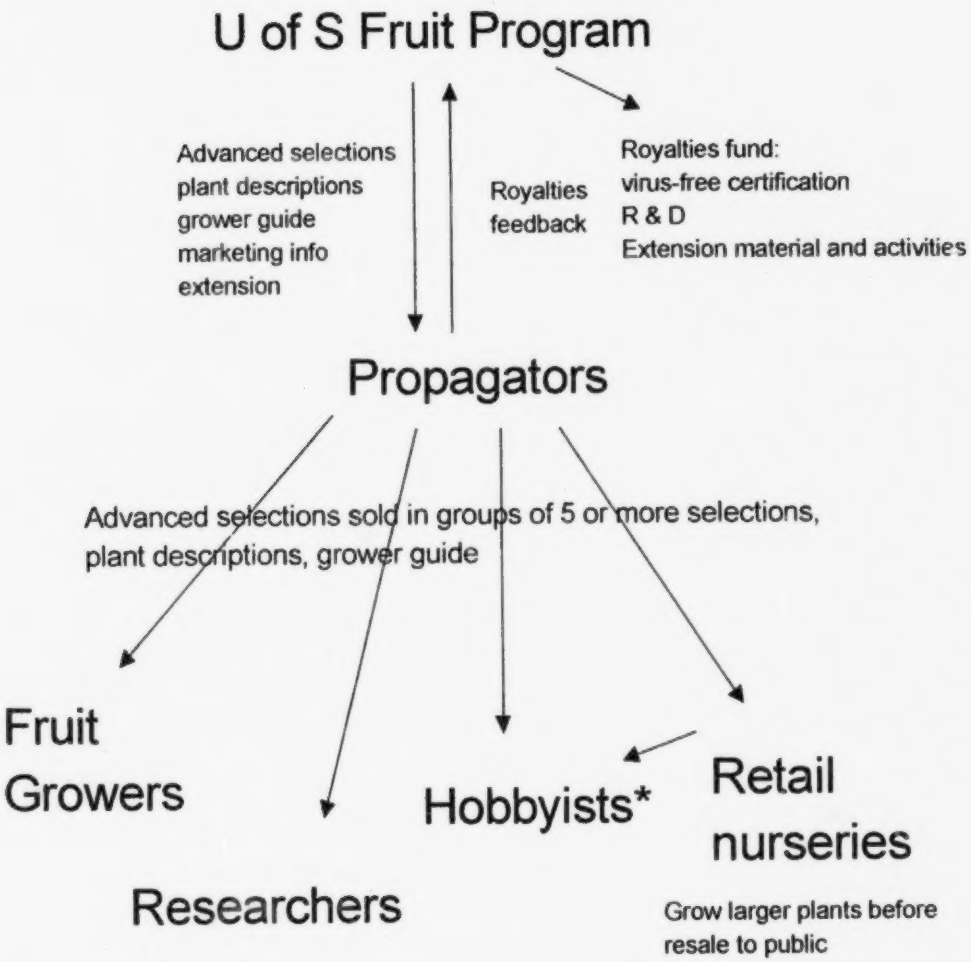
CO-OPERATIVE TESTING PROGRAM FOR NEW FRUIT SELECTIONS

Many (most?) of the largest fruit propagators in the 3 Prairie Provinces are interested in propagating our advanced selections.:

Prairie Plant Systems (SK)
D n' A Gardens (AB)
The Saskatoon Farm (AB)
Albert Robertson (A potato TC company up until now) (SK)
Jefferies Nursery (wants to trial first) (MAN)
Sunny Hills Nursery (Jim Boughen) (SK)
Blue Sky Farm (SK)

The following pages outline in flow chart format the program being developed.

Participatory Fruit Breeding Project
Phase 1: Establishment



U of S Fruit Program

Advanced selections
plant descriptions
grower guide
marketing info
extension

Royalties
feedback

Royalties fund:
virus-free certification
R & D
Extension material and activities

Propagators

Advanced selections sold in groups of 5 or more selections, plant descriptions, grower guide

Fruit Growers

Researchers

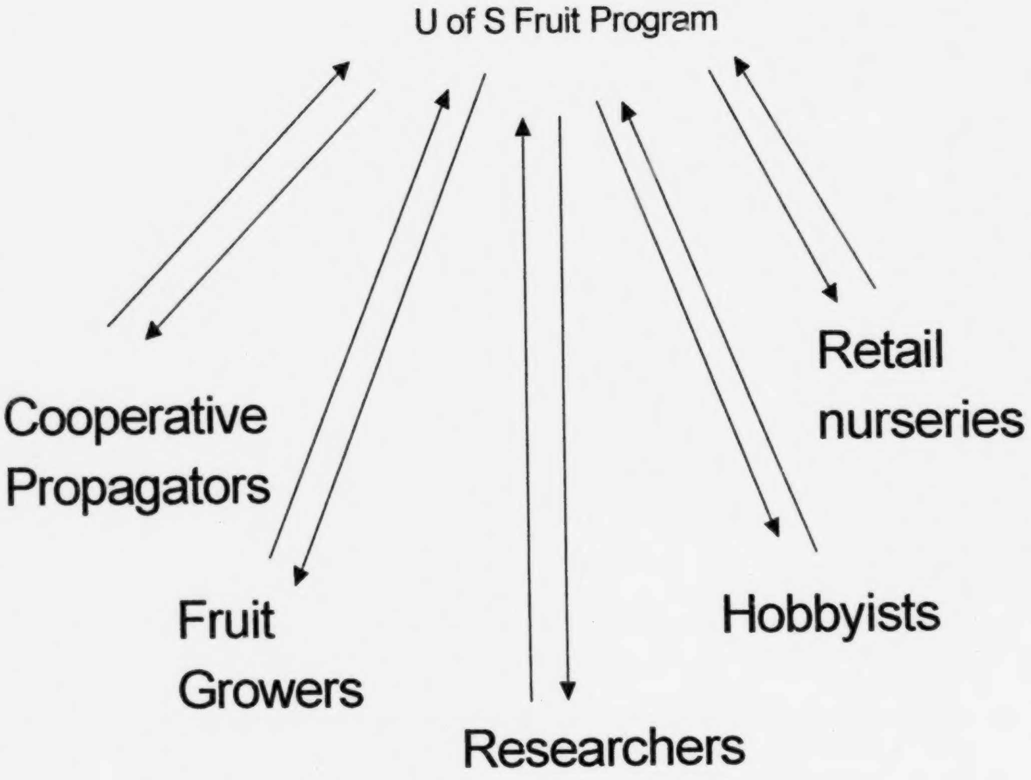
Hobbyists*

Retail nurseries

Grow larger plants before resale to public

* Propagators and nurseries could theoretically sell a complete set of 5 test trees to hobbyists. This could have appeal to many hobbyist and be a mechanism to sell more trees. For sales of single trees it would be better propagate extra numbers of already named cultivars, such as SK Carmine Jewel. With grafting, it would be possible to graft all five test varieties onto one tree..perhaps an interesting alternate for a higher priced market?

Phase 2: Evaluation



U of S Fruit Program

Cooperative Propagators

Fruit Growers

Researchers

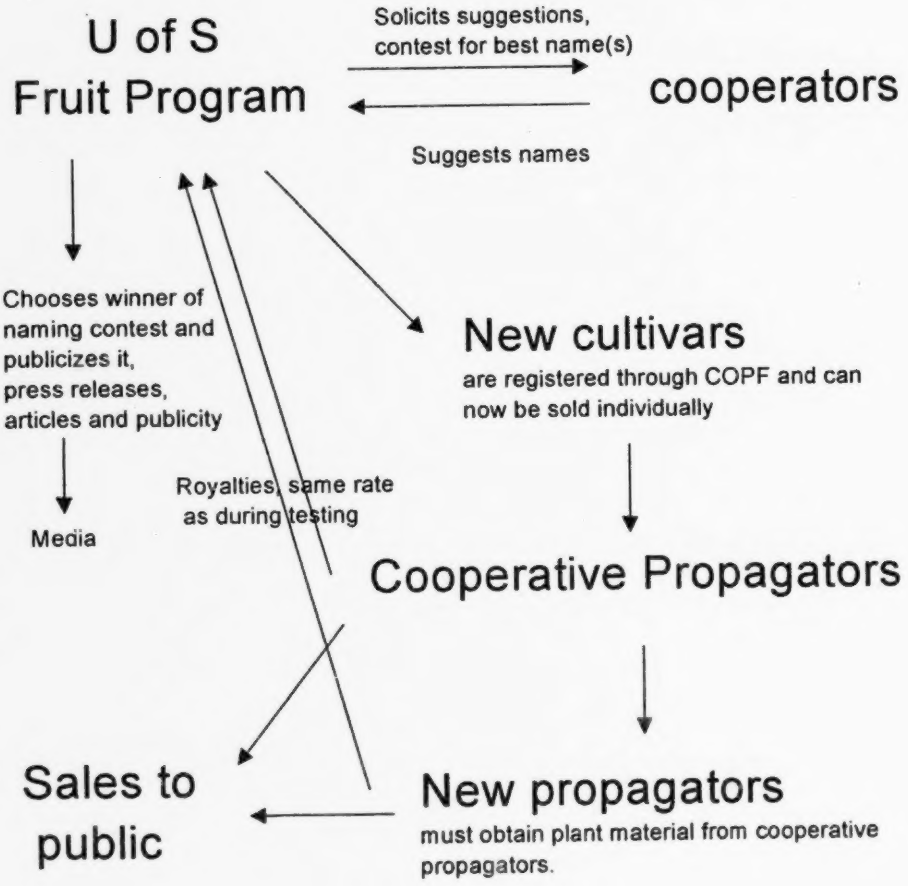
Hobbyists

Retail nurseries

Throughout the testing period the fruit breeder will encourage feedback from cooperators. This will help direct research into production methods, creation of new extension materials , and give focus to breeding selection criteria. After a number of years when the fruit trees enter full production, the breeder will:

1. carry out on-site evaluations with growers
2. Survey participants
3. Encourage feedback and discussion
4. Decide which test selections should become named cultivars and which should be discontinued, or further studied.

Participatory Fruit Breeding Project
Phase 3: Release of named cultivars



U of S
Fruit Program

Solicits suggestions,
contest for best name(s)

cooperators

Suggests names

Chooses winner of naming contest and publicizes it,
press releases,
articles and publicity

Media

Royalties, same rate as during testing

New cultivars

are registered through COPF and can now be sold individually

Cooperative Propagators

Sales to public

New propagators

must obtain plant material from cooperative propagators.

RECOMMENDATIONS

Many promising selections from this program are being evaluated at a large number of test sites. The best of the selections can be identified and introduced as named cultivars, which will provide an opportunity for competitive commercial fruit production on the prairies. Cultural practises that will enhance reliable fruit production will need to be developed to compliment the breeding work. Excellent opportunities exist for both conventional and organic fruit production and for the processed products that will result. As the new varieties produced by this program come into commercial production it will become increasingly important to develop value-added products, and to specifically select in the breeding program for various uses. The crops that can be mechanically harvested will probably have the greatest potential for increased acreage in Saskatchewan. These crops include: Dwarf Sour Cherries, Blue Honeysuckles, Raspberries, Hazelnuts, and Saskatoons. Apples and Pears many be economically feasible if Organic production is feasible. Certainly these last two have been used as fillers in a wide range of fruit products such as juices, wine and dried fruit.

Some suggest that we have advanced beyond Europe and Asia in developing apples, raspberries and cherries for climates similar to zones 2 and 3. Cultivars of pears and plums may be similar. Eurasia has advanced in developing fruit crops like blue honeysuckle. We have imported some of the best blue honeysuckle cultivars from the Vavilov Institute in Russia and we are planning to test them here. It is very important that this work continue at the University of Saskatchewan because we are the only public institution in North America developing fruit crops for a very large agricultural area, zones 2 and 3. The colder regions will become increasingly important for fruit production as much of the traditional fruit production land in B.C., Ontario, and Quebec is consumed in urban expansion. While other provinces have instituted zoning regulations to stop this erosion of farmland, the costs of production continue to soar in these regions. Farm near urban areas also have increasingly difficulties with pest control. With ample acreage, few pests, and the need to develop higher revenues per acre, we predict increasing opportunities for fruit production in the Prairie.

The strategy of developing many crops on a rotating basis while emphasising those with the best commercial potential is recommended. This will assure a rich diversity for the future while delivering new varieties in the short term. We have seen with field crops the value of diversity in the increasingly important canola and pulse crops.

REFERENCES:

Anonymous. 1991. Edible Apples in Prairie Canada. Pub. by The Friends of the Garden, Univ. of Alberta Devonian Botanic Garden, Edmonton, Alberta.

Bantle, M.R.L. 1998. An Economical Mechanical Harvester for Saskatchewan Fruit Crops: Final Report Project 93000056. Saskatchewan Agriculture and Food, Regina, Saskatchewan. p.33.

Bantle, M.R.L., R.G. St. Pierre and D. Wulfsohn. 1996. Mechanical harvesting trials on Western Canadian native fruits. Presented at the Agricultural Institute of Canada Annual Conference, July 7-10, 1996, Lethbridge, Alberta, Can. Soc. Agric. Eng. Paper No. 96-403

Beach, S. A.; N. A. Booth, and O. M. Taylor. 1905. The Apples of New York. Volumes 1 and 2. J. B. Lyon Company, Albany.

Callesen, O. 1998. Recent developments in cherry rootstock research. Acta Hort.468:219-228.

Downing, A. J. 1870. The fruits and fruit-trees of America. John Wiley and Son, New York

Iezzoni, A. and Karle,R. 1998. Sour Cherry breeding at Michigan State University. Acta Hort.468:181-185.

Iezzoni, A.F. 1996. Sour cherry cultivars: objectives and methods of fruit breeding and characteristics of principal commercial cultivars. In Cherries: crop physiology, production and uses. Edited by A.D. Webster and N.E. Looney. CAB International, University Press, Cambridge, UK.

Nelson,S.H. 1976. Propagation of Ottawa apple rootstocks by softwood cuttings. Can.J. Plant Sci. 56:511-515.

Nelson,S.H. 1978. A test for juvenility as an index of rootability in clonal apple rootstocks. Can.J. Plant Sci. 58:605-609.

Patterson, C. F. 1936. Hardy Fruits. R. and R. Clark Limited, Edinburgh, Great Britain.

Patterson, C. F. 1960. University of Saskatchewan fruit introductions 1959-1960 unpublished manuscript.

Ronald, W. G. 1978. Prairie fruit breeding co-operative (PFBC). Reports of proceedings of 34th annual meeting of the Western Canadian Society for Horticulture: 63-68.

Saunders, W. 1911. Progress in the breeding of hardy apples for the Canadian Northwest. Dominion of Canada, Dept. of Agr., Central Experimental Farm, Ottawa, Canada. Bulletin no. 68.

Stushnoff, C. 1982. Selection for cold hardiness in fruit crops based on mechanisms of low temperature survival breeding, in North America. Rep. Proc. West. Can. Soc.Hortic. Banff, Alta., The Society. 38:112-115.

Thomas, J. J. and W. H. S. Wood. 1897. The American fruit culturist. William Wood and Company, New York.

Trajkovski, V. 1996. A review of the cherry breeding program in Sweden. Proceedings of the International Cherry Symposium. Acta Hort. 410:387-388.